THURSDAY, JULY 3, 1879

THOMSON AND TAIT'S NATURAL PHILOSOPHY

Treatise on Natural Philosophy. By Sir William Thomson, LL.D., D.C.L., F.R.S., Professor of Natural Philosophy in the University of Glasgow, Fellow of St. Peter's College, Cambridge, and Peter Guthrie Tait, M.A., Professor of Natural Philosophy in the University of Edinburgh, formerly Fellow of St. Peter's College, Cambridge. Vol. I. Part 1. New Edition. (Cambridge, at the University Press, 1879.)

THE year 1867 will long be remembered by natural philosophers as that of the publication of the first volume of "Thomson and Tait." They had long been waiting for the book, and in the preface the delay was accounted for by the necessity of anticipating the wants of the other three volumes, in which the remaining divisions of Natural Philosophy were to be treated. The reader was also reminded, that if in any passage he failed to appreciate the aim of the authors, the reason might be that what he was studying was in reality a prospective contrivance, the true aim of which would not become manifest until after the perusal of that part of the work for which it was designed to prepare the way.

What we have had before us now for twelve years was, the authors reminded us, strictly preliminary matter. The plan of the whole treatise could only be guessed at from the scale on which its foundations were constructed.

In these days, when so much of the science of our best men is dribbled out of them in the fragmentary and imperfectly elaborated form of the memoirs which they contribute to learned societies, and when the work of making books is relegated to professional bookmakers, who understand about as much of one subject as of another, it was something to find that even one man of known power had not shrunk from so great a work; it was more when it appeared that two men of mark were joined together in the undertaking; and when at last the plan of the work was described in the preface, and the scale on which its foundations were being laid was exhibited in the vast substructure of Preliminary Matter, the feeling with which we began to contemplate the mighty whole was one in which delight was almost overpowered by awe.

This feeling has been growing upon us during the twelve years we have been exploring the visible part of the work, marking its bulwarks and telling the rising generation what manner of a palace that must be, of which these are but the outworks and first line of defences, so that now, when we have before us the second edition of the first part of the first volume, we are impelled to risk the danger of criticising an unfinished work, and to say something about the plan of what is already before us.

The first thing which we observe in the arrangement of the work is the prominence given to kinematics, or the theory of pure motion, and the large space devoted under this heading to what has been hitherto considered part of pure geometry. The theory of the curvature of lines and surfaces, for example, has long been recognised as an important branch of geometry, but in treatises on motion it was regarded as lying as much outside of the subject as the four rules of arithmetic or the binomial theorem.

The guiding idea, however, which, though it has long exerted its influence on the best geometers, is now for the first time boldly and explicitly put forward, is that geometry itself is part of the science of motion, and that it treats, not of the relations between figures already existing in space, but of the process by which these figures are generated by the motion of a point or a line.

We no longer, for example, consider the line *A B* simply as a white stroke on a black board, and call it indifferently *A B* or *B A*, but we conceive it as the trace of the motion of a point from *A* to *B*, and we distinguish *A* as the beginning and *B* as the end of this trace.

This method of regarding geometrical figures seems to imply that the idea of motion underlies the idea of form, and is in accordance with the psychological doctrine which asserts that at any given instant the attention is confined to a single and indivisible percept, but that as time flows on the attention passes along a continuous series of such percepts, so that the path of investigation along which the mind proceeds may be described as a continuous line without breadth. Our knowledge, therefore, of whatever kind, may be compared to that which a blind man acquires of the form of solid bodies by stroking them with the point of his stick, and then filling up in his imagination the unexplored parts of the surface according to his own notions about continuity and probability. The rapidity, however, with which we make our exploration is such that we come to think that by a single glance we can thoroughly see the whole of that surface of a body which is turned towards us, if, indeed, we are not prepared to assert that we have seen the other side too, when after all, if our attention were to leave a trace behind it, as the point of the blind man's stick might do, this trace would appear as a mere line meandering over the surface in various directions, but leaving between its convolutions unexplored areas, the sum of which is still equal to the whole surface. We are at liberty no doubt to course over the surface and to subdivide the meshes of the network of lines in which we envelope it, and to conclude that there cannot be a hole in it of more than a certain diameter, but no amount of investigation will warrant the conclusion, which, nevertheless we draw at once and without a scruple, that the surface is absolutely continuous and has no hole in it at all. Even when, in a dark night, a flash of lightning discloses instantaneously a whole landscape with trees and buildings, we discover these things not at at once, but by perusing at our leisure the picture which the sudden flash has photographed on our retina.

The reason why the phenomena of motion have been so long refused a place among the most universal and elementary subjects of instruction seems to be, that we have been relying too much on symbols and diagrams, to the neglect of the vital processes of sensation and thought.

It is no doubt much easier to represent in a diagram or a picture the instantaneous relations of things coexisting in space than to illustrate in a full and complete manner the simplest case of motion. When we have drawn our

diagram it remains on the paper, and the student may run his mind over the lines in any order which pleases him. But when we are either perceiving real motions, or thinking about them without the aid or the encumbrance of a diagram, the mind is carried along the actual course of the motion, in a manner far more easy and natural than when it is rushing indiscriminately hither and thither along the lines of a diagram.

Having pursued kinematics from its elementary principles till its intricacies begin to be appalling, we resume the study of the elements of science in the opening of the chapter on "Dynamical Laws and Principles." It is here that we first have to deal with something which claims the title of Matter, and our authors, one of whom never misses an opportunity of denouncing metaphysical reasoning, except when he has occasion to expound the peculiarities of the Unconditioned, make the following somewhat pusillanimous statement:—

"We cannot, of course, give a definition of *Matter* which will satisfy the metaphysician, but the naturalist may be content to know matter as *that which can be perceived by the senses, or as that which can be acted upon by, or can exert, force.*"

The authors proceed to throw out a hint about Force being a direct object of sense, and after telling us that the question *What is matter?* will be discussed in a future volume, in which also the Subjectivity of Force will be considered, they retire to watch the effect of the definition they have thrown into the camp of the naturalists.

Now all this seems to us very much out of place in a treatise on Dynamics. We have nothing of the kind in treatises on Geometry. We have no disquisitions as to whether it is by touch or by sight that we come to know in what way a triangle differs from a square. We have not even a caution that the diagrams of these figures in the book do not exactly correspond with their definitions. Even in kinematics, when our authors speak of the motion of points, lines, surfaces, and solids, though they introduce several modern phrases, the kind of motion they speak of is none other than that which Euclid recognises, when he treats of the generation of figures.

Why, then, should we have any change of method when we pass on from kinematics to abstract dynamics? Why should we find it more difficult to endow moving figures with mass than to endow stationary figures with motion? The bodies we deal with in abstract dynamics are just as completely known to us as the figures in Euclid. They have no properties whatever except those which we explicitly assign to them.

Again, at p. 222, the capacity of the student is called upon to accept the following statement:—

"Matter has an innate power of resisting external influences, so that every body, as far as it can, remains at rest or moves uniformly in a straight line."

Is it a fact that "matter" has any power, either innate or acquired, of resisting external influences? Does not every force which acts on a body always produce exactly that change in the motion of the body by which its value, as a force, is reckoned? Is a cup of tea to be accused of having an innate power of resisting the sweetening influence of sugar, because it persistently refuses to turn sweet unless the sugar is actually put into it?

But suppose we have got rid of this Manichæan doctrine of the innate depravity of matter, whereby it is disabled from yielding to the influence of a moving force unless that force actually spends itself upon it, what sort of facts are left us to be the subject-matter of abstract dynamics?

We are supposed to have mastered so much of kinematics as to be able to describe all possible motions of points, lines, and figures. In so far as real bodies have figures and motions, we may apply kinematics to them.

The new idea appropriate to dynamics is that the motions of bodies are not independent of each other, but that, under certain conditions, dynamical transactions take place between two bodies, whereby the motions of both bodies are affected.

Every body and every portion of a body in dynamics is credited with a certain quantitative value, called its mass. The first part of our study must therefore be the distribution of mass in bodies. In every dynamical system there is a certain point, the position of which is determined by the distribution of mass. This point was called by Boscovich the centre of mass—a better name, we think, than centre of inertia, though either of these is free from the error involved in the term centre of gravity.

In every dynamical transaction between two bodies there must be something which determines the relation between the alteration of the motions of the two bodies. In other words, there must be some function of the motions of the two bodies which remains constant during the transaction. According to the doctrine of abstract dynamics it is the motion of the centre of mass of the two bodies which is not altered on account of any dynamical transaction between the bodies. This doctrine, if true of real bodies, gives us the means of ascertaining the ratio of the mass of any body to that of the body adopted as the standard of mass, provided we can observe the changes in the motions of the two bodies arising from an encounter between them.

We then confine our attention to one of the bodies, and estimate the magnitude of the transaction between the bodies by its effect in changing the *momentum* of that body, momentum being merely a term for a quantity mathematically defined in terms of mass and motion. The rate at which this change of momentum takes place is the numerical measure of the force acting on the body, and, for all the purposes of abstract dynamics, it *is* the force acting on the body.

We have thus vindicated for figures with mass, and, therefore, for force and stress, impulse and momentum, work and energy, their places in abstract science beside form and motion.

The phenomena of real bodies are found to correspond so exactly with the necessary laws of dynamical systems, that we cannot help applying the language of dynamics to real bodies, and speaking of the masses in dynamics as if they were real bodies or portions of matter.

We must be careful, however, to remember that what we sometimes, even in abstract dynamics, call matter, is not that unknown substratum of real bodies, against which Berkeley directed his arguments, but something as perfectly intelligible as a straight line or a sphere.

Real bodies may or may not have such a substratum, just as they may or may not have sensations, or be capable

of happiness or misery, knowledge or ignorance, and the dynamical transactions between them may or may not be accompanied with the conscious effort which the word force suggests to us when we imagine one of the bodies to be our own, but so long as their motions are related to each other according to the conditions laid down in dynamics, we call them, in a perfectly intelligible sense, dynamical or material systems.

In this, the second edition, we notice a large amount of new matter, the importance of which is such that any opinion which we could form within the time at our disposal would be utterly inadequate. But there is one point of vital importance in which we observe a marked improvement, namely, in the treatment of the generalised equations of motion.

Whatever may be our opinion about the relation of mass, as defined in dynamics, to the matter which constitutes real bodies, the practical interest of the science arises from the fact that real bodies *do* behave in a manner strikingly analogous to that in which we have proved that the mass-systems of abstract dynamics *must* behave.

In cases like that of the planets, when the motions we have to account for can be actually observed, the equations of Maclaurin, which are simply a translation of Newton's laws into the Cartesian system of co-ordinates, are amply sufficient for our purpose. But when we have reason to believe that the phenomena which fall under our observation form but a very small part of what is really going on in the system, the question is not—what phenomena will result from the hypothesis that the system is of a certain specified kind? but—what is the most general specification of a material system consistent with the condition that the motions of those parts of the system which we can observe are what we find them to be?

It is to Lagrange, in the first place, that we owe the method which enables us to answer this question without asserting either more or less than all that can be legitimately deduced from the observed facts. But though this method has been in the hands of mathematicians since 1788, when the *Mécanique Analytique* was published, and though a few great mathematicians, such as Sir W. R. Hamilton, Jacobi, &c., have made important contributions to the general theory of dynamics, it is remarkable how slow natural philosophers at large have been to make use of these methods.

Now, however, we have only to open any memoir on a physical subject in order to see that these dynamical theorems have been dragged out of the sanctuary of profound mathematics in which they lay so long enshrined, and have been set to do all kinds of work, easy as well as difficult, throughout the whole range of physical science.

The credit of breaking up the monopoly of the great masters of the spell, and making all their charms familiar in our ears as household words, belongs in great measure to Thomson and Tait. The two northern wizards were the first who, without compunction or dread, uttered in their mother tongue the true and proper names of those dynamical concepts which the magicians of old were wont to invoke only by the aid of muttered symbols and inarticulate equations. And now the feeblest among us can repeat the words of power and take part in dynamical discussions which but a few years ago we should have left for our betters.

In the present edition we have for the first time an exposition of the general theory of a very potent form of incantation, called by our authors the Ignoration of Co-ordinates. We must remember that the co-ordinates of Thomson and Tait are not the mere scaffolding erected over space by Descartes, but the variables which determine the whole motion. We may picture them as so many independent driving-wheels of a machine which has as many degrees of freedom. In the cases to which the method of ignoration is applied there are certain variables of the system such that neither the kinetic nor the potential energy of the system depends on the values of these variables, though of course the kinetic energy depends on their momenta and velocities. The motion of the rest of the system cannot in any way depend on the particular values of these variables, and therefore the particular values of these variables cannot be ascertained by means of any observation of the motion of the rest of the system. We have therefore no right, from such observations, to assign to them any particular values, and the only scientific way of dealing with them is to ignore them.

But this is not all. Since these variables do not appear in the expression for the potential energy, there can be no force acting on them, and therefore their momenta are, each of them, constant, and their velocities are functions of the variables, but, since their own variables do not enter into the expressions, we may consider them as functions of the other variables, or, as they are here called, the retained co-ordinates, and of the constant momenta of the ignored co-ordinates.

From the velocities as thus expressed, together with the constant momenta, we obtain the contribution of the ignored co-ordinates to the kinetic energy of the system in terms of the retained co-ordinates and of the constant momenta of the ignored co-ordinates. This part of the kinetic energy, being independent of the velocities of the retained co-ordinates, is, as regards the retained co-ordinates, strictly *positional*,[1] and may be considered for all experimental purposes as if it were a term of the potential energy. The other part of the kinetic energy is a homogeneous quadratic function of the velocities of the retained co-ordinates. In the final equations of motion neither the ignored co-ordinates nor their velocities appear, but everything is expressed in terms of the retained co-ordinates and their velocities, the coefficients, however, being, in general, functions of the constant momenta of the ignored co-ordinates.

We may regard this investigation as a mathematical illustration of the scientific principle that in the study of any complex object, we must fix our attention on those elements of it which we are able to observe and to cause to vary, and ignore those which we can neither observe nor cause to vary.

In an ordinary belfry, each bell has one rope which comes down through a hole in the floor to the bellringers' room. But suppose that each rope, instead of acting on one bell, contributes to the motion of many pieces of machinery, and that the motion of each piece is deter-

[1] The division of forces into motional and positional is introduced at p. 370.

mined not by the motion of one rope alone, but by that of several, and suppose, further, that all this machinery is silent and utterly unknown to the men at the ropes, who can only see as far as the holes in the floor above them.

Supposing all this, what is the scientific duty of the men below. They have full command of the ropes, but of nothing else. They can give each rope any position and any velocity, and they can estimate its momentum by stopping all the ropes at once, and feeling what sort of tug each rope gives. If they take the trouble to ascertain how much work they have to do in order to drag the ropes down to a given set of positions, and to express this in terms of these positions, they have found the potential energy of the system in terms of the known co-ordinates. If they then find the tug on any one rope arising from a velocity equal to unity communicated to itself or to any other rope, they can express the kinetic energy in terms of the co-ordinates and velocities.

These data are sufficient to determine the motion of every one of the ropes when it and all the others are acted on by any given forces. This is all that the men at the ropes can ever know. If the machinery above has more degrees of freedom than there are ropes, the co-ordinates which express these degrees of freedom must be ignored. There is no help for it.

Of course, if there are co-ordinates for which there are no ropes, but which enter into the expression for the energy, then, if the motion of these co-ordinates is periodic, there will be "adynamic vibrations" communicated to the ropes, and by these the men below will know that there is something peculiar going on above them. But if they pull the ropes in proper time, they can either quiet these adynamic vibrations or strengthen them, so that in this case these co-ordinates cannot be ignored.

There are other cases, however, in which the conditions for the ignoration of co-ordinates strictly apply. For instance, if an opaque and apparently rigid body contains in a cavity within it an accurately balanced body, mounted on frictionless pivots, and previously set in rapid rotation, the co-ordinate which expresses the angular position of this body is one which we are compelled to ignore, because we have no means of ascertaining it. An unscientific person on receiving this body into his hands would immediately conclude that it was bewitched. A disciple of the northern wizards would prefer to say that the body was subject to gyrostatic domination.

Of the sections on cycloidal motions of systems, we can only here say that the investigation of the constitution of molecules by means of their vibrations, as indicated by spectroscopic observations, will be greatly assisted by a thorough study of this part of the volume.

We have not space to say anything of what to many readers must be one of the most interesting parts of the book—that on continuous calculating machines, in which pure rolling friction is taken from the class of unavoidable evils, and raised to the rank of one of the most powerful aids to science. Rolling and sliding have been more than once combined in the hope of obtaining accurate measurements, but the combination is fatal to accuracy, and these new machines, one at least of which has been actually constructed and used, are the first in which pure rolling friction has had fair play given it as a method of mechanically accurate integration.

A method is also given of combining a number of disk, globe, and cylinder integrators, so as to form a machine the motions of two pieces of which are related to each other by a differential equation of any given form. These machines all work in a purely statical manner, that is, in such a way that the kinetic energy of the system is not an essential element in the practical theory of the machine (as in the case of pendulums, &c.), but has to be taken into account only in order to estimate the magnitude of the tangential forces at the points of contact which might, if great enough, produce slipping between the surfaces. Thus, by means of a machine, which will go as slowly as may be necessary to keep pace with our powers of thought, motions may be calculated, the phases of which in nature pass before us too rapidly to be followed by us.

In the original preface some indications were given of what we were to expect in the remaining three volumes of the work. We hope that the reason why this part of the preface is omitted in the new edition is that the work will now go on so steadily that it will be unnecessary to preface performance by promise.

J. CLERK MAXWELL

ARTIFICIAL MANURES

On Artificial Manures, their Chemical Selection, and Scientific Application to Agriculture. A Series of Lectures given at the Experimental Farm at Vincennes, during 1867 and 1874–5. By M. Georges Ville. Translated and Edited by W. Crookes, F.R.S. (London: Longmans and Co., 1879.)

THOSE who take up this volume with the hope of finding the chemistry of artificial manures fully treated will be much disappointed. Not only are many of the commonest manures scarcely mentioned, but some of the most important and practical aspects of the subject are never noticed. The behaviour of manures after they come in contact with the soil is surely of the greatest importance. Chemical investigations have long ago proved that some of the ingredients of manure—as phosphoric acid and potash—are firmly held in combination by the soil, while others—as nitric acid, chlorine, and soda—are feebly retained, and readily pass away in the drainage water after rain. It has also been abundantly proved that though ammonia is firmly retained by a fertile soil, it rapidly undergoes conversion into nitric acid, which is easily washed out. The practical conclusion from these facts is plain. Diffusible manures must be applied only when the crop can make immediate use of them. Now, though M. Ville speaks voluminously concerning the application of phosphates, nitrates, and ammonium salts, no reference to the facts just indicated is to be found in his book, beyond the mere statement that clay is capable of temporarily retaining potash and ammonia.

The lectures of M. Ville are chiefly occupied by the consideration of the present state of agriculture in France, and by the recommendation of a system of artificial manuring of which he regards himself as the inventor. The condition of French agriculture is clearly, as a whole, very low; the existence of the peasant and small farmer is only maintained by the exercise of much thriftiness and self-denial. To improve this condition M. Ville very

properly recommends the consolidation of the land in large farms, and the liberal use of artificial manures.

The "normal manure" which M. Ville recommends is in its simplest form a mixture of superphosphate, saltpetre, and gypsum, thus supplying nitrogen, phosphoric acid, potash, and lime. Instead of employing the nitrate of potassium, a mixture of nitrate of sodium or sulphate of ammonium with chloride of potassium may be substituted; the manure then becomes a "normal homologous manure." This normal manure embraces all the chief elements of plant food which it may be necessary to apply to the land. It is unnecessary, however, to apply the entire mixture to every crop. Each crop demands a preponderance of one or other of the constituents of the manure; this "dominant" constituent is therefore increased when the manure is prepared for a particular crop; or the elements of the whole manure may be distributed through a rotation of crops, each crop receiving the part specially suited to it. Stated thus, we can only approve the recommendations which M. Ville has made; they are in fact, in their last-named form, precisely carried out by all our best farmers in the present day. Though, however, we have correctly stated the teaching which may be gathered from his book, there are many passages in the lectures which urge the return to the land of all the potash, phosphates, and lime which the crops have removed, a proceeding which is on many soils quite unnecessary, and therefore, very unremunerative.

M. Ville recommends that each farmer should set aside a small portion of his land to be treated with experimental manures. One plot of this ground would receive the normal manure; a second the same without nitrogen; a third the same without phosphates; a fourth the same without potash; while another plot would be left entirely without manure. By growing crops on these plots the farmer would learn in the most certain manner what elements of plant food were chiefly deficient in his soil in relation to the crops he wished to grow. This is excellent advice; no better could be given. It is only by such experiments that the true condition of the soil can be revealed; and it is only by thus testing the effect of manures before applying them on a large scale that an economic return can reasonably be expected. France is apparently ahead of us in the practical use of such experiments. Thanks to the centralisation which places the control of everything in the hands of the Government, field experiments of this description are now in progress in thirty-four farming schools throughout the country, while simpler experiments on the effects of manures have been established in connection with 350 day schools. In England we have but one place at which such experiments are thoroughly carried out, namely, Rothamsted.

Are we, then, to credit M. Ville with the discovery of the great effect to be obtained from artificial manures, or of the best mode of applying them? He claims for himself the honour of having discovered the principles he sets forth, and compares himself with Lavoisier, and his detractors with the detractors of that great man, and concludes:—"We must allow time to complete the work of justice, and give to every one his proper place." We will in reply simply mention a few dates. The famous field experiments at Rothamsted commenced in 1843; in the very first year trials were made of the effects of phosphates, potassium, magnesium, and ammonium salts. These field experiments have been carried on continuously up to the present time, and the effect of every variety of combination of manure has been shown in the fields devoted to wheat, barley, beans, clover, roots, pasture, and potatoes. That nitrogen should form the "dominant" constituent of a manure for wheat, and phosphates the dominant constituent of a manure for turnips, was clearly proved in the first two or three years of the experiments; and by 1849 the character of potash as the proper dominant in the case of beans and clover was also established. With these experiments M. Ville is well acquainted. Our last date shall be taken from his own book. The first field experiments made by M. Ville at Vincennes commenced in 1860.

The book contains several extraordinary statements. It would take too long to discuss M. Ville's views as to the assimilation of the free nitrogen of the air by all crops, but especially by the leguminosæ; immense quantities of nitrogen are, according to him, thus acquired. We are curious to know what authority he has for stating that when an animal is fed on hay one-third of the nitrogen is lost "in the act of digestion," and that another third is lost during the fermentation of the animal manure, so that only one-third of the original nitrogen is at last returned as manure to the land.

We cannot conclude without calling attention to the extremely untrustworthy character of the figures throughout the book. On p. 54 the mould on an acre of soil weighs 400,000 tons; on p. 180 it weighs 1,600 tons. On p. 353 the weight of resin yielded by an acre of pine trees is given as 4–5 cwts., but immediately after it is stated to be 1,122–1,540 lbs. The quantities of nitrogen to be applied are a complete puzzle. To take a single instance: On p. 238 we are told that to obtain a good crop of beet we must apply 70 lbs. of nitrogen per acre. On p. 357 the quantity has risen to 176 lbs. On pp. 367 and 368 the formulæ for the beet manures are given; each formula is stated to contain 187 lbs. of nitrogen; but on looking at the ingredients only 83 and 85 lbs. of nitrogen are found to be contained by the ammonium salts and nitrates employed. Finally, on p. 374 we are told that the nitrogen applied to beet should amount to 70–88 lbs. per acre. What are we to believe?

Both the old and new chemical notations are employed in the course of the book. R. W.

OUR BOOK SHELF

Lecture on the Gault. By F. G. H. Price. (Taylor and Francis, 1879.)

THIS pamphlet contains considerably more than a lecture, embodying a list of the French and English works upon the Gault, which have come under the author's notice, and nearly forty pages of tables of fossils.

The description of the gault at Folkestone has been amplified from that read by the author before the Geological Society.[1] He maintains his subdivision of the gault at Folkestone into beds, and endeavours to correlate with them, to some extent, the gault to the west. The outcrop at Eastbourne is separately described, and found to contain an unexpectedly long list of fossils. The Blackdown beds are included in the Gault, which is to be greatly regretted, for there is every reason to suppose that

[1] *Quart. Journ. Geol. Soc.*, 1874, vol. xxx. p. 342.

they are of much newer, and most probably upper greensand age: to tabulate their fauna with that of the gault, lessens the working value of the tables materially. The upper gault only is thought to be present in the Isle of Wight, where it is 100 feet thick. The little that is known of the gault in the Midland Counties is collected together, and that of Cambridgeshire and the red chalk at Hunstanton is briefly described. A few pages are devoted to the gault in France, a few lines to that of Switzerland, but no mention is made of any equivalents in Germany or in Belgium. The pamphlet contains in a compact form a deal of information upon the gault, which would have to be sought elsewhere in many publications, and it may prove of value to students at home and abroad.

The author believes that the bands which are characterised by fossils peculiar to them at Folkestone, can be traced elsewhere in England and in France. The range through the gault of most fossils is probably less restricted than is imagined, but some species are apparently strictly confined to narrow zones at Folkestone, although closely allied species abound in cretaceous rocks in England, and even America. It is likely that zones of fossils were due to the gradual alteration of depth which enabled certain gregarious forms to exist on the spot for a very short time only after their first migration to it. Their presence elsewhere would not prove that the zone was a continuous one; it would only indicate that at some period, not necessarily a synchronous one, the sea at that other spot had fulfilled the conditions of depth, &c., under which alone the particular species could exist. The same view applies to the idea that upper gault only was deposited in the Isle of Wight. There is no reason to suppose that deposition did not proceed there in the lower gault age, and it is more probable that the sea was, during the whole gault period, only fitted to receive that form of silt, and those fossils which are known at Folkestone as upper gault. The lower gault is spoken of by the author as a shallow sea deposit gradually deepening to the chalk, but the President of the Geological Society has stated his opinion that the gault is an extremely deep sea deposit, while Mr. Gwyn Jeffreys has collected much evidence to prove that the chalk was formed in shallow water. Whether we accept them or not, the views of such distinguished men should find a place in a work intended to be exhaustive.

Travels and Researches among the Lakes and Mountains of Eastern and Central Africa. From the Journals of the Late J. Frederic Elton, H.B.M. Consul at Mozambique. Edited and Completed by H. B. Cotterill. Maps and Illustrations. (London: Murray, 1879.)

ONE cannot read Consul Elton's Journals without feeling how great a loss his death has been not only to the cause of the native African, but to African exploration. Elton was only thirty-seven years of age when he succumbed to the hardships of African exploration, but he had already done more than his share of hard and useful work. The handsome and beautifully illustrated volume before us deals with his observations and adventures in Africa from 1873, when he went to Zanzibar as Vice-Consul to his death in December, 1877, when trying to push from the north end of Lake Nyassa to the coast at Dar-es-Salaam. Much of the earlier part of the volume tells of the work Elton did in putting down the slave-trade in the dominions of the Sultan of Zanzibar. In carrying out this work he had to visit most of the coast from Zanzibar to beyond Mozambique, as well as Madagascar, and with the details of his more immediate mission, is mixed up a good deal of geographical information. He carried on his works of benevolence and exploration on his appointment as Consul of Mozambique. The chief novelty of the volume, however, is in the second part, in which the story of the journey from the north end of Lake Nyassa north-east to the coast is told. Here Elton, Cotterill, and their companions broke on fresh ground, and made substantial additions to our knowledge of African geography and African people. With the main results of this journey we are already familiar, through the description of Mr. Cotterill at the Geographical Society and elsewhere. Elton left Mozambique in July, 1877, Livingstonia at the south end of Nyassa in September, and the north end on October 15. The country traversed was mainly hilly, rising in the Konde Mountains, north-west of Nyassa, to 12,000 feet. Elton speaks of the country as the "Garden of Africa." The party were delayed for a time in Merere's Country in the Konde Mountains, by one of those little wars, which so often embarrass African explorers, and during the delay some hardships had to be endured, which no doubt told on Elton's health. On December 19 he succumbed to what seemed sun-stroke, and was buried under the shade of a baobab in South Ushekke. Cotterill conducted the expedition to Bagamoyo, over what is comparatively well-known ground. In completing the narrative of the expedition and editing his late fellow-traveller's journals, in preference to publishing a narrative of his own, he has acted with an unselfishness which deserves to be acknowledged. The book is altogether one of much interest. The Rev. A. E. Eaton contributes a short Appendix on the Natural History of the Kungu Fly, out of which the natives to the north of Nyassa make cakes.

Conic Sections—The Method of Projections. By Rev. S. Bolton Kincaid, M.A. (London: Stanford, 1877.)

THIS book has only recently met our notice; it consists of a series of twenty-nine propositions deriving proofs of many of the chief properties of the ellipse by the method of circular projection. We have not come across any special novelty in the little book, nor have we detected many mistakes, though the lettering, from the use of like letters, we have found in many cases confusing. The figures face the text, and the circle figure is over the elliptical one; they are in many cases very roughly turned out by the engraver.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

Comet 1879 *c* (Swift)

THE following observations may be useful to some of your readers:—On June 25 the comet was compared five times with the star O.A. 3268, with a ring micrometer (power 35); on June 28 it was compared eight times with the star Dm +71°, 184 by means of a bar reticule with power 70. The comet has a bright spot near the centre which, on June 25, seemed to me to be nearly equal to a ninth magnitude star; but on June 28 it was much fainter, although easy to observe with precision after 11h. 30m. The diameter appears to be 2′ or 3′ in my telescope (of 4½ inches aperture) but I cannot see any trace of the tail mentioned by Mr. Swift. The comet is, however, immersed in the twilight now existing at midnight.

1879.		G.M.T.		Appt. R.A.		Appt. Dec.
		h. m. s.		h. m. s.		° ′ ″
June 25	...	11 57 49	...	2 49 37·1	...	+68 41 37
June 28	...	11 30 20	...	2 51 13·3	...	+71 52 18

1, Vanbrugh Park, Blackheath G. L. TUPMAN

The Mechanical Theory of Earth-Heat

IN reference to Mr. J. P. Lesley's inquiry as to whether plicated coal-beds are generally converted into anthracite, it has occurred to me that during a residence upon the Somersetshire coal district, thirty years ago, I recollect visiting the Vobster coal-pits, on the northern edge of the Mendip hills. The coal-seams are there exceedingly disturbed. One seam of coal was

said to have been pierced three times by a vertical shaft. Yet the coals are not anthracite. The Vobster pits are very fiery. The Radstock pits, where the coal is horizontal, not so; but they are worked in higher beds.

By reference to the Commissioner's report to Parliament, 1871, it will be seen (p. 38) in Mr. Prestwich's report on the Nettlebridge Valley coals, where Vobster is situated, that my recollections are confirmed; "bituminous coal" and "disturbed condition" being alike attributed to these coal beds.

With respect to the general question of the mechanical theory of earth-heat, I would respectfully refer Mr. Lesley to my examination of the theory in the *Philosophical Magazine* for October, 1875. O. FISHER

Harlton, Cambridge

On the Origin of Certain Granitoid Rocks

IN a paper by me "On the Pre-Cambrian Rocks of Shropshire," read before the Geological Society on the 11th inst., I call attention to certain granitoid and gneissic rocks in Primrose Hill, at the south-west end of the Wrekin. Associated with these metamorphic strata in such an irregular manner as to suggest an eruptive origin is a compact felspathic rock with minute quartz grains, which I at first presumed to be a quartz felsite. On submitting specimens to Prof. Bonney, F.R.S., for microscopic examination, he declared the rock to be clastic, and closely allied to the hälleflintas, which Dr. Hicks assigns to his Arvonian group. Certain observations recently made in south-west Shropshire, suggested to me a transition between the hälleflinta and the granitoid types, and, on communicating my suspicions to Prof. Bonney, he stated that a similar connection had been suggested by his microscopic examination. This morning I hammered over Primrose Hill foot by foot, and I have the satisfaction of announcing the fullest confirmation of our suspicions. In the same block, the compact hälleflinta is frequently mixed up with granitoidite and hornblendic gneiss. In some cases, the metamorphism has taken place only near the surface, as if produced by atmospheric agencies; in others the crystallisation occurs in nests, while in others there is a gradual transition in mass from a compact to a granitic structure. This passage of hälleflinta into granite has obviously important theoretical applications.

Wellington, Salop, June 21 C. CALLAWAY

Migrations of Birds

I NOTICED some time ago a communication in NATURE respecting this subject, stating that it would be instructive and interesting alike if naturalists would record any data they may have collected on this subject. For years now this matter has had my careful attention, and I therefore forward a few notes for the last two seasons, and also put forward the hope that observers stationed in other parts of the United Kingdom will contribute information of a like nature. I would also say that the weather noted applies to the night—the time, by the way, generally chosen for migratory movements.

Vernal Migration, 1878

Dates.		Species.	Remarks.
April	4	... Gray Wagtail	In pairs on the trout streams for nesting season. Weather clear, warm westerly breezes.
,,	4	... Tree Pipit	In full song and seen for first time; westerly breezes.
,,	15	... Redstart	In full song in Encliffe Wood and Rivelin Valley; warm westerly breezes, clear.
,,	15	... Willow Warbler	Numerous, arrived during last night.
,,	15	... Ring Ousel	Numerous and full of song.
,,	18	... Chiffchaff	In small numbers, westerly breezes, very warm, close.
,,	19	... Swallow	One specimen seen; westerly breezes, fine and clear.
,,	19	... Cuckoo	Heard and saw flying over the busiest streets of Sheffield at 4.30 A.M.
,,	22	... Whitethroat	One heard; dull and misty drizzling rain, W.S.W.
,,	22	... Martin and Sand Martin	Numerous, in company with swallows in the Derwent Valley.
,,	28	... Blackcap Warbler ...	First seen, but silent; warm breezes, S.E.S.
,,	29	... Whinchat	Seen for first time, weather dull, S.E.S.
,,	29	... Common Sandpiper ...	Seen for first time, in pairs, in Rivelin Valley.
May	3	... Landrail	First heard, weather dull and gloomy, W.
,,	6	... Spotted Flycatcher ...	First seen, very wet night, wind direct, S. These birds are still solitary.

Vernal Migration, 1879

Dates.		Species.	Remarks.
Feb.	10	... Song Thrush	Arrived in night; dark and cloudy, wind W.
,,	10	... Blackbird	Arrived in night; dark and cloudy, wind W.
March	20	... Yellow Wagtail	Numerous.
,,	20	... Pied Wagtail	,,
,,	29	... Willow Warbler	One specimen seen, somewhat feeble, silent; wind W. by S., night dull and showery, snow only left ground day before. Never known this species so early before. Average time being April 5.
,,	29	... Greenfinch	Again in usual haunts after being entirely absent during the winter, with the exception of one pair seen in a garden in Sheffield.
April	9	... Chiffchaff	Saw and heard in young fir plantations at Hollow Meadows, S.W. and westerly winds.
,,	21	... Curlew	In pairs at breeding grounds on moors.
,,	21	... Ring Ousel	Numerous on moors, mostly in pairs; no song.
,,	24	... Tree Pipit	Arrived: dull and showery weather, easterly winds.
,,	26	... Willow Warblers and Chiffchaffs	On the evening of 25th not a bird was seen; on morning of 26th the birds abounded and their cheery notes are heard on every side. The night was dark and showery (new moon), wind S.
,,	26	... Cuckoo	Heard in Lees-hall Wood. This bird has arrived during past night, doubtless in same flight as willow warblers, &c.
,,	28	... Swallow...	Seen in Meersbrook Park; weather showery and dull, wind light from S.W., moonlight.
,,	29	... Whinchat	Seen in Meersbrook Park; weather showery and dull, wind light from S.E., moonlight.
May	2	... Wheatear	On moors, full of song.
,,	2	... Common Sandpiper ...	Rivelin and Redmires dams, in pairs. This species has been here some few days.
,,	2	... Redstart	This bird has now arrived, but only seen in small numbers. Cold easterly winds, moonlight.
,,	5	... Wryneck	Saw on Rivelin moors; solitary and uttering its whistling notes. Cold easterly winds.
,,	8	... Landrail and Whitethroat...	Heard in meadows; very scarce; probably came last night with a cold south-westerly breeze.
,,	12	... Sand Martin...	Skimming over the waters in small numbers. This species is remarkably late; wind N.W. by W.
,,	13	... Blackcap	Singing in densest covers, and very shy. This species is very late. South-westerly breeze, clear night.
,,	17	... Martin	Saw a pair of these birds; they are very late as compared with previous seasons. Southerly breezes and very showery.
,,	24	... Swift	One seen on the borders of the Rivelin Moors. South-westerly breezes and very showery.
,,	26	... Spotted Flycatcher ...	One specimen seen, silent and somewhat wary. N.W. by W., light, and showery moonlight night.

Such are a few extracts, taken *verbatim*, from my note-book; they might have been considerably increased, and the time of departure noted, as well as the arrival of our winter migrants, but I fear I have already trespassed too greatly on your valuable space. I sincerely trust that this interesting subject will be more fully discussed and studied by your correspondents and readers; for in that way many of the difficulties enshrouding the movements of the feathered tribes will be overcome.

Heeley, near Sheffield, June 9 CHARLES DIXON

Glow-worms *v.* Snails

YOUR correspondent, Mr. R. S. Newall, has unconsciously reversed the natural condition of affairs in his note (NATURE, vol. xx. p. 197). The heading should have been as above. Glow-worms *devour* snails, which are their natural food. The particular snail in question had probably been attacked by one of the glow-worms, which had left some of its phosphorescent matter adhering to it, and this occasioned the idea that it was showing through the body of the mollusk. Possibly in this case the snail may have proved too large for the glow-worm. An allied insect, *Drilus flavescens*, somewhat rare in this country, and not luminous, is, so far as the female is concerned, seldom

found excepting inside the shells of species of *Helix*, the animal of which it had previously devoured. R. McLachlan

Lewisham, June 27

Your correspondent, R. S. Newall, is upon the wrong tack, I think. His glow-worm was probably eating the snail, and not *vice versâ*.

In Kirby and Spence's "Entomology" I read: "Snails give sustenance to *Drilus flavescens*, a beetle, and its singular apterous female in the larva state, as well as to the larvæ of glow-worms." Is it not probable that the same food suits the imago state of the insect?

I have often found glow-worms in snail shells, and have always considered slugs and snails to be the natural food of the *Lampyris noctiluca*. R. Greenwood Penny

Bishopsteignton, Devon

Frogs and Glow-flies

Mr. Newall may be, perhaps, interested with the following extract from Darwin's "Botanic Garden," Canto iv. p. 149, note:—

"In Jamaica, in some seasons of the year, the fire-flies are seen in the evenings in great abundance. When they settle on the ground, the bull-frog greedily devours them; which seems to have given origin to a curious, though cruel method of destroying these animals; if red-hot pieces of charcoal be thrown towards them in the dusk of the evening, they leap at them, and, hastily swallowing them, are burnt to death."

I was told a few days ago of a cat which used to search for and eat glow-worms. It was suggested that she took them for *lights*. George Henslow

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Intellect in Brutes

The following instance of sagacity in a cat has just been related to me by a friend who knew both the cat and its owner well. The latter, who lived at Ragusa Vecchia, in Dalmatia, was too poor to be able to provide food for the cat; the animal was therefore obliged to cater for himself, and was well known as a thief in the neighbourhood. One day one of the children was being sent off to school without any breakfast; the cat, hearing him sobbing for hunger, immediately went off, and returned with a piece of bread he had stolen from a baker hard by, and brought it to the child. The same thing happened another day, and he came back, dragging along a piece of meat bigger than himself. On crossing the threshold a bit of bone caught in a hole, so puss miawed till some one came to his help. This same cat, who was constantly catching birds on the roof, slept with some pet birds in a cage without attempting to touch them.

Ragusa, Austria, June 18 Margaret Evans

I send you the following instance of intelligence in dogs:—Last summer, when on a visit at the château of my son-in-law, M. Richard Waddington, Deputé, near Rouen, I had taken a walk in the grounds, accompanied by some of the family, and two favourite dogs, named respectively Minos and Rhadamanthus, followed the party, as usual, throughout the stroll. When nearing the house, on the return, my young grand-daughter remarked that Minos had lost his collar. The party came to a halt, debating whether it was worth while to go back on a searching expedition, for the pleasure grounds are somewhat extensive, and the dogs had been rambling away from the paths among long grass. Both Minos and Rhadamanthus evidently seemed to listen to the debate. It was decided to make the search at a venture, and, without saying a word to the dogs, the party commenced to retrace their steps. As a rule, these two dogs are inseparable; wherever the one goes the other goes, and invariably the two follow any members of the family when strolling about the place. At this juncture, however, Rhadamanthus, not having lost a collar, and having no special interest in the proposed search, went on her solitary way home to the stables; but Minos kept with the party, walking on the gravel path—and this for some distance—when suddenly he took to the meadow, commenced running, and presently he was observed to stop and remain fixed with his head pointed downwards, partly buried in the tall grass. Naturally he was followed. The point of his nose was in contact with the collar! Could any child of man, under similar circumstances, have displayed more *thoughtful sagacity* than did *each* of the above dogs on the above occasion? The one thought she was not wanted, and having had enough play, wisely went home, whilst the other, thinking that his presence was requisite, wisely returned with the searching party.

When in Bute, some years ago, I heard from a gentleman, perfectly trustworthy, that a large Newfoundland dog, belonging to a friend of his, was observed one night by its owner lying concealed under his bed—a strange circumstance, because the dog was forbidden to enter the house at night. The owner, being struck by this singular occurrence, resolved not to disturb the creature, and, getting into bed, kept himself awake to watch events. It was not long before a sound was heard in the passage, a faint light was seen through the key-hole, the door opened, and instantly the dog flew from under the bed, and, springing forward, brought a man to the ground, the gentleman's own servant, who, accompanied by another fellow, was there for the purpose of robbery. Chas. Popham Miles

Vicarage, Monkwearmouth

Having read Mr. Peach's letter on "Intellect in Brutes," as shown by the sagacity he witnessed in his dog, I have been asked to send a similar anecdote, which I have often told to friends. Many years ago my husband had his portrait taken by T. Phillips, sen., R.A., and subsequently went to India, leaving the portrait in London to be finished and framed. When it was sent home about two years after it was taken, it was placed on the floor against the sofa, preparatory to being hung on the wall. We had then a very handsome large black and tan setter, which was a great pet in the house. As soon as the dog came into the room he recognised his master, though he had not seen him for two years, and went up to the picture and licked the face. When this anecdote was told to Phillips, he said it was the highest compliment that had ever been paid to him. X.

Some years ago a fine arts exhibition was held at Derby. A portrait of a Derby artist, Wright, was thus signalised: "The artist's pet dog distinguished this, from a lot of pictures upon the floor of the studio, by licking the face of the portrait."

Derby Henry Clark

Butterfly Swarms

With reference to the swarms of butterflies referred to by M. Forel, in Nature, vol. xx. p. 197, it may be interesting to mention that *Vanessa cardui* is this year very common in the south of England. This butterfly is known to all English lepidopterists to be "periodical"—in some seasons it occurs in great numbers, in others—perhaps for several years in succession—not one specimen is to be seen.

Last season (1878) I saw no specimens, nor did I hear of any about here. It seems, therefore—in such a bad season for insects as the present—impossible to consider the abundance of the species in England to be the result of "local fecundity." Whence, therefore, come these specimens? and is the periodical abundance of the species in Britain due to local causes or migration? J. H. A. Jenner

4, East Street, Lewes, July 1

THE KILBURN SHOW

It is difficult to estimate the disadvantages with which the Agricultural Exhibition at Kilburn has had to contend. So large a show must always be somewhat unwieldy, however skilfully planned, but the melancholy wet season has enormously increased the difficulties of arrangement, and we may add that fairly to study the implements and miscellaneous exhibits was quite impossible up to the time of our going to press. A few jottings set down at random concerning such instruments, operations, and specimens as drew our attention while in the yard on Monday must suffice on the present occasion. Visitors were supposed to view the exhibits from the avenues between the long rows of sheds; but these avenues, once grass, were transformed into roads of mud, in every condition of matter between the solid and liquid states. There were no paths across the sheds, and as most of the implements and other exhibits were not so arranged as to be approachable on more than one side, the difficulty of examining objects of interest was frequently insurmountable.

Perhaps the comparative loan collection of farm implements is the most noticeable feature of the whole show. The paucity of labels and the filthy condition of the ground notwithstanding, the rollers, ploughs, harrows, drills, threshing, winnowing, and reaping machines, are full of interest. Of the actual specimens shown, but few, if any, date back further than the last century, while the majority belong to the first half of the present. The reapers, including Bell's reaper of 1826, form an instructive series.

When, about the year 1850, steam was becoming more generally used for agricultural operations, an immense impetus was given to the improvement of farm machinery. Richard Trevithick's portable engine, made at Hayle Foundry, in 1811, and put upon Sir C. Hawkins's farm at Trevithen for working a threshing machine, is an historical agricultural relic far too curious to be allowed to return, after the Kilburn Show is closed, to its prosaic duties in Cornwall. It should be secured for the Patent Museum at South Kensington. It must be regarded as inaugurating the practical use of steam on the farm. The later steps in the progress of steam cultivation may be studied in this loan collection and in the modern implement sheds with tolerable completeness.

Before leaving the subject of the loans exhibited at Kilburn, we may direct our readers to a case exhibited by the Secretary of State for India. It is to be found close to the house in which the plans for farm-buildings are arranged, and in a line with one of the historical implement sheds. The case in question contains specimens of wheat from our Indian Empire, and is accompanied by a map, some remarks on the quality of the wheats, and some statistics. From the latter we learn that India produces 40 million quarters of wheat, of which but 1·3 millions were exported in 1877; that the demand for wheat of the whole world is at the most but 25 million quarters; and that the United Kingdom requires an average import of 11 million quarters, in addition to her home production of the same quantity. Had chemical analyses of some of these samples of Indian wheat, together with their mill-products, been added to this exhibit, it would have been still more instructive.

In the same shed with the Indian wheats there are shown a series of seventeen cases illustrative of the composition and nutrition of the human body. These are lent by the South Kensington Museum and from what is known as the "Circulating Food Collection." It constitutes a small replica of the most characteristic parts of the Food Collection at Bethnal Green, and like the latter, has been arranged and fully described by Prof. Church. It supplies in an exact yet popular form an immense amount of information concerning the elements and compounds of the human body and of food; and concerning the amount and nature of a day's ration, the equivalents of foods, the analysis and adulteration of alimentary products, the qualities and testing of waters. It has been lent to several provincial exhibitions already, and forms an admirable instrument of popular instruction.

Turning to another department of the show we notice, amongst the raw materials used in the manufacture of manure, some specimens of native phosphates which claim our attention. The search for anything that can be made into superphosphate has certainly been most exhausting. As one supply fails a new one is discovered. The Canadian apatites shown at Kilburn are very fine. Some hexagonal prisms and pure blue crystalline masses are quite museum specimens. Some samples of what are called Russian coprolites are exhibited on Stand 615. They are large and have a well-marked radiate structure, closely resembling that often seen in iron pyrites.

We do not recollect ever having before seen the seed of the locust bean, *Ceratonia siliqua*, prepared for food by simple splitting, as shown in a fine sample (No. 11,081) on Stand 595. Some specimens of selected or pedigree wheat, on Stand 629, are noticeable.

The artificial drying of hay and some other crops is likely to be more extensively employed before long. Mr. W. A. Gibbs, the inventor, shows some improved forms of his implement for this purpose. They effectually get rid of the excess of moisture in the materials submitted to the process of artificial desiccation without stewing them. One machine can dry out 35 per cent. of water from hay at the rate of twenty loads a day. Another instrument, of which a model is also shown, is specially adapted for drying tea, coffee, manures, hops, and fruit.

It is impossible to do justice, in a single set of brief jottings like the present, to any of the subjects we have handled. We can but direct attention to some of the characteristic features of the stands, and to two or three out of the thousands of specimens shown. We should like to have dwelt upon numbers of inventions to which we have no space to allude; but we cannot refrain from noticing the exquisitely ingenious application of hydraulic pressure to the automatic opening, and, what is more curious, the automatic closing, of entrance gates by the pressure of the passing vehicle. The interval between the opening and the spontaneous closing of these gates can moreover be regulated to a nicety by a previous adjustment. A large working model of this invention will be found at Stand 141, the patentee being W. Walton, of Runiley, Manchester. We must also note a charming chromolithographic diagram of the colours acquired by the metal in tempering steel from the pale straw proper to "scrapers for brass" through shades of orange, red, and purple to the deep blue of "springs." This was issued as a supplement to the *Ironmonger* of April 5, 1879, and is shown at Kilburn on the stand appropriated to that paper.

We have not space to speak of the many admirable features of the showyard, nor even of the delightful little train of steam tramcars working on rails of less than two feet gauge. But we may return to the subject of the Kilburn Show next week.

MAJOR PINTO'S AFRICAN JOURNEY

MAJOR SERPA PINTO has been lecturing in Lisbon to a distinguished audience on his journey across Africa from Benguella to Durban. He apologises for the disjointed character of his lecture, for which he had no time to prepare, and which, therefore, cannot be taken as anything like a complete account of the results of his journey. There is some likelihood of his soon being in London, and probably then he may give us a more systematic account of what he has been able to gather in the interesting region through which he passed. A good deal has been said of the large natural history and other collections he has made, and if these be such as they have been represented, science will certainly be much indebted to the gallant Major, who has tried to revive the glories of the old days when Portugal was in the front rank of exploring nations. A good many difficulties were met with at the beginning as usual, and Major Pinto deemed it advisable to separate himself from his companions Ivens and Capello, who took a more northern route, and as they had various scientific instruments with them, including such as were suitable for observations in terrestrial magnetism, possibly they may have some important contributions to make to science.

It is difficult to make much out of Major Pinto's rambling talk, which often reminds us of the vague and wonderful stories told by the simple travellers of old. He certainly seems to have made important rectifications in the hydrography of South-West Africa, especially of that flat table-land about 12° S. and 18° E., where within a few paces one can drink of the water of the sources of the Zambesi, Coanza, and Cubango, and where it can easily

be conceived that in wet seasons the oozing waters will have some difficulty in making up their minds whether to take their course to the Atlantic, the Indian Ocean, or by the Cubango south to the sands of the Kalahari Desert. Major Pinto's real starting-point was Bihé, the eastern limit of Portuguese West Africa. Going south and east by the Kalahari Desert, through the Transvaal, he came upon the scene of the Anglo-Zulu strife, and was safely carted to Durban. He suffered the usual hardships of desertion by followers, starvation, fighting hostile tribes, and narrow escapes from cataracts. To the west of Bihé he discovered the source of the Cubango, which, he states, loses itself in the Kalahari Desert, after overflowing to form Lakes Ngami and Macaricari, the latter of which is sometimes dried up. There is no connection, he says, between the Cubango and Cuando, the latter, after receiving many feeders, finding its way to the Zambesi, where, at its mouth Livingstone gave it the name of Chobé. A good deal of his information Pinto seems to have derived from a map drawn by a Bihé native. The river Cuqueima, he tells us, is an affluent of the Coanza, west of the Cubango. At its source the Cuando is a little rill, but soon becomes navigable, many of its tributaries being navigable also. Going through Ungo-é-Ungo, between the Cuango and Upper Zambesi, he found the ground all miry, an immense marsh; "water covered everything." From the Bihean's map he found that the most southern source of the Lualaba lies between those of the Liambai, or Zambesi, and the Luengué, and in 12° S. lat., "like those of the other rivers of Africa." The Luengué, or Cafuque, the "Cafue" of Livingstone, a tributary of the left bank of the Zambesi, the Major states, has not a single cataract, and should form the real key to Central Africa. The river that connects Lakes Bangweolo and Moero, he states, is not the Lualaba, but the Luapula; did not Livingstone say so? Lualaba, Pinto says, is the name given to the west arm, which extends to 12° south, and must be considered the real source of the Congo, and not the Chambeze, which enters the east end of Lake Bangweolo. On a recent map of Africa, we find the Lualaba placed as described, and as to which is the source of the Congo, it is a matter of opinion as to what "source" means.

The Zambesi seems to be more notorious for cataracts than even the Lualaba—Congo; Pinto and his men descended thirty-seven; he saw thirty in the space of an hour and a half "that had never been mentioned by any one."

At the junction of the Cuando and Zambesi, Major Pinto found an English naturalist from the Cape, Dr. Bradshaw, "who was reduced to the greatest misery," wandering about barefoot, and carrying in his hands a pair of shoes, with only a tattered shirt and a pair of trousers on. Dr. Bradshaw's extreme misery he seems to have borne with equanimity; he gravely presented his carte-de-visite, taken in London, to his Portuguese fellow-explorer. He was shooting birds and collecting animals for "the English museums." Near the same place a French missionary family befriended the sorely beset traveller, and helped him out of his difficulties. At the beginning of his journey, at Caconda, he met another naturalist, a Portuguese, Anchietta, who has been twelve years in Africa, and "has enriched one of the best African museums in the world, that of the Lisbon Polytechnic School, which is under the direction of Dr. Bocage." Have the treasures of this African Museum ever been described? Anchietta was more fortunate than the miserable English naturalist, who received the major in his drawers. The Portuguese, on the contrary, received his compatriot "in the woods, wearing a white necktie and a dress coat, and offered us tea in cups of porcelain of Sèvres." Still Anchietta, with all his attention in the wilds of Africa to the usages of ceremonious Europe, seems to be a hard-working naturalist.

The only other point in Major Pinto's lecture we need notice is his observation as to a race of white Africans, which will recall to the reader what Stanley says about the white inhabitants of the lofty mountain near the Albert Nyanza. We shall let the Major tell what he observed for himself:—

"I one day noticed that one of the carriers was a white man. He belonged to a race entirely unknown up to the present day. A great white people exists in South Africa. Their name is Cassequer; they are whiter than the Caucasians, and in place of hair have their heads covered with small tufts of very short wool. Their cheek-bones are prominent, their eyes like those of the Chinese. The men are extremely robust. When they discharge an arrow at an elephant the shaft is completely buried in the animal's body. They live on roots and the chase, and it is only when these supplies fail them that they hold any relations with the neighbouring races, the Ambuelas, from whom they obtain food in exchange for ivory. The Cassequeres are an entirely nomadic race, and never sleep two nights in the same encampment. They are the only people in Africa that do not cook their food in pots. They wander about, in groups of from four to six families, over all the territory lying between the Cuchi and the Cubango. It would seem that from a crossing of the Cassequeres with the negroes of other races, sprang those mulattoes of the South whom the English call bushmen. The latter are, however, better off than the Cassequeres, and use pots in cooking their food, while their dispositions are good, though quite opposed to civilisation."

We cannot doubt the accuracy of the Major's observations, though we should require to know more of the curious people he speaks of before pronouncing on their origin and affinities.

Altogether it will be seen that Major Pinto, while hardly having a claim to be ranked among "the foremost of explorers," has done a piece of good and useful work amid a good many dangers, work creditable to himself and his country, which, we trust, will be stimulated by his example to do what she ought for the complete exploration of that part of Africa which forms, so to speak, the back garden of her West Coast colonies.

THE COMPARATIVE ANATOMY OF MAN[1]

I.

HUMAN anatomy, as ordinarily taught, has for its end simply the knowledge of the structure of the body of the man we have most to deal with in our practice, that is, the European man, in his usual average development. No cognisance is taken of the deviations from this ordinary but known type, except as individual variations, which have their principal interest in any interference they may cause with our diagnosis or treatment of the diseases or injuries to which our frame is liable.

The comparative anatomy of man goes beyond this. Instead of aiming at describing a general average man, by overlooking, or purposely eliminating, all deviations from the normal standard, it is specially occupied in studying the differences between one man and another, estimating and classifying these differences, and especially discriminating between such differences as are only individual variations (variations which, when extreme, are relegated to the department of the teratologist) and those that are inherited, and so become characters of distinct groups and races of the human species. Physical anthropology, moreover, extends its range beyond merely comparing and registering these differences of structure. It also occupies itself with endeavouring to trace their cause, and the circumstances which may occasion their modifications. It endeavours, also, to form a classification of the different groups of mankind, and so to throw

[1] Abstract of Prof. Flower's Hunterian Lectures, delivered at the Roya College of Surgeons, commencing on Wednesday, March 5.

light upon the history and development of the species. These are all exceedingly difficult and complicated problems.

As an example of one of the problems which the student of the Comparative Anatomy of Man sets himself, may be quoted the relation of the size of the brain to that of the rest of the body in different races and different individuals. An important contribution to this much-vexed question appeared in the last number of the French *Revue d'Anthropologie*, by M. Gustave Le Bon, in which the author, among other things, endeavoured to show that in lower races, and uncivilised conditions of the higher races, the brains of men and women were comparatively equal in size and weight, but that with elevation in the scale and advance of culture, the differences between the sexes increased, the women's brain remaining stationary, while that of the men augmented. There are, however, some fallacies in the statistics quoted in support of this proposition, which might apply to the women of France, although not to so great a degree as M. Le Bon seems to imply. The lecturer showed that in England, according to the best information yet obtained, the proportional size of the female brain to the male was as 9 to 10, very nearly the same as in the lowest and least cultivated of the races quoted by M. Le Bon.

As regards the relative size of the head in men, it seems probable from the investigations of Mr. Francis Galton and others, that on the whole men with the greatest amount of intellectual capacity have large heads, although this is by no means always the case. Small heads are frequently accompanied by great energy.

The Australians were described in last year's lectures, but as they are a very interesting race, being both socially and physically the most different from ourselves, it may be as well to go over some of their principal characters again.

Their habits are very primitive, their only domestic animal being the native dog, and their only weapons the boomerang, spear, and lance, having no bows and arrows. They have not acquired the art of pottery making. One of their principal characteristics is the small size of the brain-cavity compared with that of a European, the largest not coming up to the size of the average Italian peasant. Since last year five Australian skulls have been added to the museum, which are all extremely characteristic of the race. The average capacity of these five is 1,234 c.c., while the average of five ordinary European skulls is 1,574 c.c.

Another characteristic of the skull is that it is long and narrow; the cephalic index, or relation of the greatest breadth in the parietal region to the extreme length, which is taken as 100, being on the average 71 or 72. The super-orbital ridges are extremely pronounced, and the orbits are elongated, and short from above downwards. The nose is short and wide below, and the jaws project forwards. The skin of these people is dark, and their hair is black, but not curly.

The Tasmanians are in some respects allied to the Australians, and in others differ greatly from them.

Tasmania was discovered in 1642 by Abel Tasman, but it was not until 1777, when Capt. Cook visited it, that the intercourse between the English and the Tasmanians commenced. In 1803 it became an English colony. The race is now entirely extinct, the last man having died in 1869, and the last woman in 1876.

Unfortunately, but few skulls have been preserved, and we have very little information about this curious and interesting race. Their habits seem to have been very primitive; they had no domestic animals, not even the native dog, and no boomerang, their only weapons being a lance and a club or "waddy."

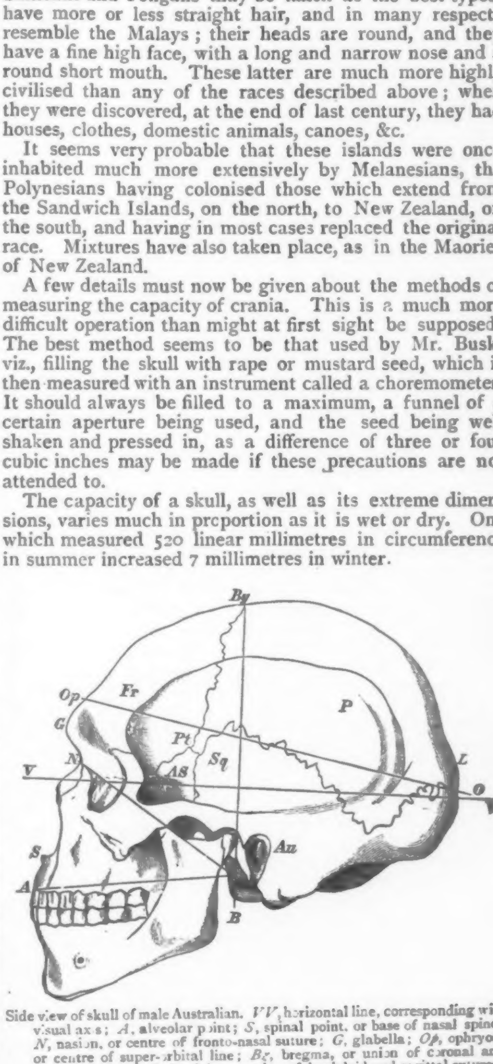
The skull is very characteristic, the parietal part being broader than in that of the Australians, and the hair is woolly, something like that of a negro, a microscopic section showing it to be flattened and elliptical, while straight hair is more or less cylindrical. They have probably been isolated from all other races for a great length of time, though it is likely that Australia was once inhabited by a people resembling them.

The islands of the Pacific Ocean proper are inhabited by two extremely distinct and different races, which are, however, often much intermixed. One of these, the Papuans or Melanesians, are very like negroes, having woolly hair, broad noses and mouths, and low orbits; the skull is long and narrow, and more like the Australian type. The other—the true Polynesian—of which the Samoans and Tongans may be taken as the best types, have more or less straight hair, and in many respects resemble the Malays; their heads are round, and they have a fine high face, with a long and narrow nose and a round short mouth. These latter are much more highly civilised than any of the races described above; when they were discovered, at the end of last century, they had houses, clothes, domestic animals, canoes, &c.

It seems very probable that these islands were once inhabited much more extensively by Melanesians, the Polynesians having colonised those which extend from the Sandwich Islands, on the north, to New Zealand, on the south, and having in most cases replaced the original race. Mixtures have also taken place, as in the Maories of New Zealand.

A few details must now be given about the methods of measuring the capacity of crania. This is a much more difficult operation than might at first sight be supposed. The best method seems to be that used by Mr. Busk, viz., filling the skull with rape or mustard seed, which is then measured with an instrument called a choremometer. It should always be filled to a maximum, a funnel of a certain aperture being used, and the seed being well shaken and pressed in, as a difference of three or four cubic inches may be made if these precautions are not attended to.

The capacity of a skull, as well as its extreme dimensions, varies much in proportion as it is wet or dry. One which measured 520 linear millimetres in circumference in summer increased 7 millimetres in winter.



Side view of skull of male Australian. *VV*, horizontal line, corresponding with visual axis; *A*, alveolar point; *S*, spinal point, or base of nasal spine; *N*, nasion, or centre of fronto-nasal suture; *G*, glabella; *Op*, ophryon, or centre of super-orbital line; *Bg*, bregma, or union of coronal and sagittal sutures: *L*, lambda, or union of lambdoid and sagittal sutures; *O*, occipital point; *Au*, auricular point, or centre of external auditory meatus; *B*, basion, or centre of anterior margin of foramen magnum; *Pt*, ptereon, or point where the frontal (*Fr*), parietal (*P*), squamosal (*Sq*), and alisphenoid (*AS*) bones meet.

The circumference of a skull is taken by passing a tape round it from a point called by Broca the *ophryon*, which

is the centre of a line taken just above the supra-orbital ridge or glabella, to the *occipital point*, or most prominent point of the occiput. The division commonly made between the anterior and posterior parts of the skull is by a line drawn from the middle of the external auditory meatus, or *auricular point*, to the *bregma*, or point where the coronal and sagittal sutures meet. The skull of a gorilla differs greatly from that of a European in the diminution of the portion situated behind this line, and the Australian cranium approaches the former where it differs from the latter, the posterior half being smaller than in the European.

The facial angle, or angle made by the profile with a horizontal line, is obtained by placing the skull in such a position that the axis of vision is horizontal. This is done by passing a rod exactly through the centre of the anterior opening of the orbit, and through the optic foramen. By means of a square, the amount of projection in front of or behind any given point can then be ascertained.

The three points forming what is known as the facial triangle are the *basion*, or centre of the anterior margin of the foramen magnum, the *nasion*, or centre of the fronto-nasal suture, and the *alveolar point*, or middle point of the upper jaw. The length is usually taken from the ophryon, but some take it from the glabella. The breadth is the greatest breadth in the parietal region.

Narrow skulls are called *dolichocephalic*, and broad ones *brachycephalic*. Taking the length as 100, if the index of breadth is above 80 the skull is brachycephalic; if below 75, dolichocephalic; while if it lies between these numbers it is called *mesocephalic*.

The height is taken from the basion to the bregma.

The form of the orbit varies much. The orbital index, or relation of the length (taken as 100) to the breadth, is very low in the Australians, the average being about 80. The form of the nose is characteristic both in races and individuals; the width compared with the height gives the nasal index. This varies much in individuals, but general averages are very important. The average nasal index of Australians is 57. Broca calls those races whose nasal index is lower than 48, *leptorhine*; between this and 53, *mesorhine*; and above 53, *platyrhine*.

The name *metopic* has been given by Broca to those skulls in which the suture between the frontals remains open in the adult. It generally closes up at the end of a year or two, and if it does not unite then, it rarely does afterwards. In European races this metopism is seen in about one cranium in ten, while in Australians and other low races it is extremely rare, as in monkeys.

The different races of men have been classified into two great groups according to the character of the hair, viz., the *Ulotrichi*, or woolly-haired people, and the *Leiotrichi*, or smooth-haired people. Mr. Charles Stewart has shown that, besides the difference in the microscopical structure of woolly and straight hair already mentioned, there is a difference in their mode of growth. The follicle in which an ordinary hair is developed is straight, while in the case of woolly hair it is curved, thus giving the hair a spiral twist. The woolly-haired people inhabit the greater part of Africa, and also a chain of islands extending from Tasmania to New Guinea and the Andaman Islands. These latter, or oceanic negroes, differ considerably from the former, or African negroes, and also differ very much among themselves. They may be divided into two distinct branches, an eastern and a western, and it is very difficult to determine whether they all arose from the same stock. In the eastern branch the people are nearly all characterised by high, narrow heads, much compressed at the sides, and features resembling the Australians.

The Museum of the College of Surgeons has lately received an interesting addition to the collection, viz., a dried man, painted red and otherwise ornamented, and fixed on a sort of hurdle, which was found in a hut on Darnley Island, in Torres Strait. The head of this man is less dolichocephalic than that of most Papuans, but it had probably been artificially compressed in infancy, many of these people having this peculiar custom. The mouth is large and projecting, but the nose is better formed than in the Australians.

When the Spaniards took the Philippine Islands they found them chiefly inhabited by Malays, but also in the wilder parts by a small race which they named Negritos. These have black complexions, woolly hair, and negro-like features. They perhaps extend as far north as to the south of Japan, but they are best marked in the Andaman Islands, where the race retains its purity.

The Andaman Islands consist of a long narrow chain of four principal islands, the Great Andamans, separated by narrow channels, as well as some smaller ones, called the Little Andamans. The first reliable notice of these islands is by some old Arab voyagers in the 9th century. No European traveller visited them until the end of last century. In 1788 a convict station was established at the south end, at a place which was called Cornwallis. This was soon abandoned, and another settlement made on the north. This, again, however, was given up, and it was not until November, 1857, that the Government once more took up the question and established a settlement on the site of Cornwallis, which is now called Fort Blair. For four or five years the natives were very shy, and the accounts of them are very unsatisfactory. They are now, however, becoming civilised, the English governors having built houses for them, and allowing them a certain quantity of food.

Although this chain of islands is only about 140 miles long, there are as many as nine distinct tribes speaking different languages. During the last year Mr. Man has sent over a valuable collection of their manufactures, and these show that in some respects they occupy a higher grade of civilisation than the Australians, Tasmanians, &c.

In the Little Andamans the people built beehive-like houses, but in the Great Andamans they had no permanent houses or clothes, the substitute for the latter being a thick coat of mud and pig's grease. A good deal of taste is shown in the manner in which this clothing is ornamented, one man being seen with half the body red and the other half yellowish, and ornamented by zigzag lines. A favourite ornament is a necklace made of the finger-bones of deceased relatives.

The Polynesians have a very general custom of preserving the bodies both of friends and enemies; the Borneans preserve their enemies, but the Andamanese give the preference to their friends. A widow often wears her husband's skull round her neck as an ornament.

The Andamanese do not cultivate the ground, but they are very expert with the bow and arrow. They cook their food, which consists principally of wild pigs and fish. They make canoes, hollowed out of the trunks of trees, and also a rough kind of pottery, simply moulded by the hand. There is no proof that they ever practised cannibalism, notwithstanding the frequency with which the charge has been brought against them.

There is much difference in the descriptions of travellers of the features and general characters of these people; some say that they are all very much alike, and others that they vary considerably both in form and features and character of hair, which is usually extremely black, close, and woolly. A section shows it to be nearly as flat as that of a South African Bushman. They, however, generally keep their heads shaved. All photographs hitherto sent to Europe show a very close general resemblance. The head is round, the forehead broad and upright, the nose small and straight, and the lips not very thick or projecting. They are a very small race, the average height being under five feet, the women being

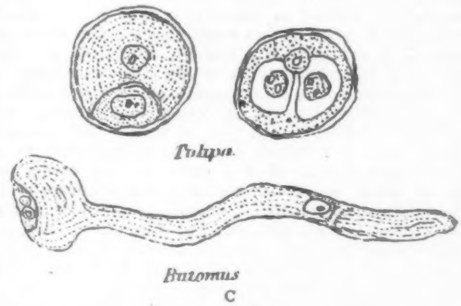
shorter than the men. There are, in fact, only three other races which are equal or approximate to them in smallness, viz., the Bushmen, the inhabitants of Tierra del Fuego, and the Lapps. The name of *Mincopie* has often been applied to these people, but it does not appear to be now used in the islands.

(*To be continued.*)

ON POLLEN PLANTS

THE evolution of the vegetable cell—using the word evolution as defined by Herbert Spencer—is a subject of immense interest that is now engaging the attention of some of the most scientific of the botanists. While the important researches of Carl Nägeli on cell-structure and cell-development can never be over-estimated, yet in these more recent times we are greatly indebted to the original and remarkable researches of Eduard Strasburger, which have thrown a flood of light on the subject, and opened out for it new and as yet untrodden by-paths. His thoughtful work, "Ueber Befruchtung und Zelltheilung," ought to be in the hands of every student. It is not here purposed to analyse the contents of this volume, now more than eighteen months on our shelves, but in it, we fear somewhat overlooked, we find the subject of the cellular-structure of the "pollen grains" in the angiosperms first mentioned, at least, in very recent times, and we are glad to perceive that the facts relating thereto have been recently restudied, and in some detail, by Fredr. Elfving, of Helsingfors, under the eye of Strasburger, and in his physiological laboratory at Jena.

We adopt for convenience the ordinarily received division of plants, in which the flowering plants, or those having the sex-cells developed in connection with phyllomes, are separated from the so-called flowerless plants, in which the sex-cells are formed on thallomes. All the more recent manuals of botany assert that the two groups of the former, the gymnosperms and the angiosperms, are differentiated, the one from the other, by certain striking peculiarities relating to their reproductive systems. One of these is that in the former the pollen-grains are multicellular, and that in the latter the pollen-grains are unicellular, a nice, and it ought to be an easily ascertained distinction, but unfortunately one that turns out on investigation not at all true. In the pollen-grains, or, as we would prefer to call them, the pollen-plants of the gymnosperms, there are all the essentials of an adult and independent form, that is to say, the protoplasmic contents of the pollen plant divide into two or more cells, of which one takes upon itself the growth and functions of the pollen tube, and the other remains with no such functional power, but at most plays the feebler part of a vegetative cell. There is thus, as it were, a thallus formed, one cell of which performs the function of an antheroidal or male cell. All this has been for some time known to be the case in the gymnosperms of which our cone-bearing trees and shrubs may serve as familiar types; but in the angiosperms, embracing nearly all our showy flowering herbs, shrubs, and trees, despite Strasburger's researches published in 1877, it is still most generally stated that inside the inner coat of the pollen-grain there is but a single protoplasmic mass which gives rise to the pollen tube. So far as this difference in the pollen goes, it will now probably not be again insisted on, for a glance at the very copious figures drawn from nature by Mr. Elfving will satisfy the most sceptical that the angiospermous pollen-grain is really a compound body, entitled to rank as a thallus, and in which, as in the gymnosperms, there are both functional and vegetative cells. The researches culminating in this memoir were chiefly made during the summer session of 1878 in the Botanical Institute at Jena. The pollen was cleared by means of a 1 per cent. solution of osmic acid, and then stained and preserved in a carmine-glycerine fluid. If the outer coat be not too dense, the contents can be seen through it after from one to two days' steeping in osmic acid. In order to see the growth of the pollen tube, recourse must be had to artificial culture; for this purpose many sorts of solutions were used, and these of very different degrees of condensation, but in the end the author came back to a simple solution of 1 to 25 per cent. of sugar. Some pollen plants required but weak solutions, others strong ones. The strength of the solution found in certain cases most useful is given in the details of the experiments. The culture upon most were generally made in the dark, and at a summer temperature, but some grown in daylight succeeded admirably. The orchids are referred to as affording most excellent subjects for these investigations. On three plates the different forms of pollen-plants to be met with in some twenty-three species of plants are represented. Of these we select that of *Tulipa gesneriana*, in which the vegetative cell happens to be very large (A in figure), and it very frequently divides, as seen at B, also that from *Butomus umbellatus* (C), showing the



vegetative cell and the tube. In this figure the side walls are not represented. The chief results of these researches are collected together as follows:—The pollen-grain in the angiosperms becomes divided into two cells, generally a larger and a smaller one; the latter, the "vegetative" cell, by a further division, becomes developed into a two- or often a three-celled thallome. This vegetative cell, or these vegetative cells, are only separated from the larger cell by a wall of cortical plasm, (ectoplasm, Vines), but this, in particular instances, can become formed into a firmer membrane (cellulose ?). The pollen tube is the result of an outgrowth of the larger cell.

In the gradual growth of this it may happen that the vegetative cell or cells will wander into the pollen tube, the wall of the larger cell having become obliterated, or they will remain free in the cavity of the mother-cell, often becoming spindle or half-moon-shaped.

The nuclei are often peculiarly fashioned, but with the exception of the Cyperaceæ no instance of a division of the nucleus of the larger cell was observed.

All the pollen plants described by Elfving belong to the sections either of the "wind-wafted" or the "insect-borne" forms. The study of the structure of the pollen plants of such cleistogamous flowers as those recently described by Bennett, such as some of the violets, wood sorrel, &c., may reveal some interesting facts. In them there would seem to be a greater individuality; the very behaviour of their pollen tubes is so different that they would appear as if they had a more independent basis; but this is rather a subject for research than for conjecture. In the meanwhile we may note how many apparently sure landmarks have been, in the botanist's country, lately thrown down by the researches of Warming, Strasburger, and now Elfving. It will be difficult by and by to invent neatly-

worded definitions to separate the sub-kingdoms, classes, and sub-classes of the vegetable kingdom. Modern research is now all destructive, nor seems it to have a thought as yet of proceeding on the lines of scientific construction.

E. PERCEVAL WRIGHT

OUR ASTRONOMICAL COLUMN

OLBERS' COMET OF 1815.—The Royal Society of Sciences of Haarlem have offered a prize for a new determination of the elements of this comet, founded upon the whole series of observations which remain in a form admitting of more accurate reduction than they have yet received, by the use of improved positions of the comparison stars and a calculation of the effect of perturbations, while the comet was visible, with the more precise values of the planetary masses which we now possess. Bessel, in his final memoir upon this comet, not only investigated the elements of the orbit from the *ensemble* of the observations in the form in which they were known to him in 1815, but essayed to determine the effect of planetary attraction upon the epoch of next return to perihelion, which he fixed to February 9, 1887, but he found that the period of revolution resulting from the observations in 1815, was liable to a probable error of ± 101 days. Unless the semi-axis major admits of determination within narrower limits, a recomputation of the perturbations would lose much of its value and interest, and accordingly the Haarlem Society, in stating the terms of the prize, limit the investigation now demanded to a definitive calculation of the orbit of the comet in 1815, at least we so understand the notification in *Astronomische Nachrichten*, No. 2,264. Allusion is made to NATURE, vol. xix. pp. 268, 366, where we gave references to publications in which the observations of this comet that admit of a new reduction are to be found. The Society at the same time offer a prize for a critical examination of Serpieri's theory of the zodiacal light, "especially if it is to be sought within or without the earth's atmosphere," and it does not clearly appear from the article in the *Astronomische Nachrichten*, whether one prize is intended to apply to the two subjects; we can hardly suppose that this is the case, as it seems unlikely that any one person would engage upon problems of so widely different a character.

THE NEW COMET.—The elements of the comet discovered by Mr. Lewis Swift do not bear resemblance to those of any comet previously computed, and it does not appear that the body is one of any special interest. The perihelion passage took place towards the end of April, and the comet is now slowly receding from the earth. From the direction of its path, so far as position is concerned, it might remain visible for a considerable time, but its brightness is stated to be sensibly diminishing.

THE COMET 1759 (III.).—The following orbit of this comet by Mr. Hind rests upon a new reduction of some of the observations made at Paris, and upon Cassini de Thury's last observation as given by Pingré.

Perihelion passage, 1759, Dec. 16·84108 G.M.T.

	°	′	″	
Longitude of perihelion	138	28	35	Mean equinox 1760·0.
,, ascending node ...	79	50	4	
Inclination	4	52	31	
Log. perihelion distance	9·9848692			

Motion—retrograde.

This is the comet which became suddenly visible in Western Europe on January 8, 1760, when its distance from the earth was within 0·075 of the earth's mean distance from the sun.

VARIABLE STARS.—The following are Greenwich times of geocentric minima of Algol according to Prof. Schönfeld's elements, from the middle of July to the middle of October:—

	h.	m.		h.	m.		h.	m.
July 15 ...	12	29·2	Aug. 27 ...	12	37·4	Sept. 22 ...	7	54·4
18 ...	9	17·8	30 ...	9	25·9	Oct. 6 ...	15	57·6
Aug. 4 ...	14	9·1	Sept. 16 ...	14	17·2	9 ...	12	46·2
7 ...	10	57·7	19 ...	11	5·8	12 ...	9	34·9
24 ...	15	48·9						

The rise in brightness of *Mira Ceti* to its maximum on September 11 may be well observed this summer. S Cancri will be at a minimum on September 18 at 10h. 4m. On the variations of the latter star Schönfeld's memoir published at Mannheim in 1872 may be advantageously consulted.

GEOGRAPHICAL NOTES

THE new number of the Geographical Society's periodical contains Mr. Keith Johnston's notes on "Native Routes in East Africa, from Dar-es-Salaam towards Lake Nyassa," accompanied by a very interesting map, in which are embodied the particulars gleaned by Mr. Johnston from native travellers. This paper is followed by Prof. Geikie's lecture on geographical evolution, of which an abstract appeared in NATURE, vol. xix. p. 490, and several pages are next devoted to a not very happy attempt to present the salient geographical features of Mr. Ryall's account of his explorations in Western Thibet, which forms one of the appendices of the *General Report* of the operations of the Survey of India for 1877-8. Among the geographical notes we find intimations that the science lectures are to be discontinued, and that the Council have arranged to provide means of instruction and training for intending travellers. There is also a note of Mr. M. C. Doughty's visit to El-Hejjer, a reported Troglodyte city in North-west Arabia, which disposes of singular fables that have been accepted by some learned Orientalists.

THE question of the availability of elephants in African exploration, lately so much discussed, is now about to be put to the crucial test of experiment. The four elephants presented by the Indian Government to the King of the Belgians for the use of his expedition have arrived safely at Zanzibar, and have been landed near Dar-es-Salaam, not, however, without some difficulty, as the following extract from a letter written by a lady who witnessed the scene will show:—"We never thought the first elephant could get alive to shore. It swam more than a mile in distance, and was in the water for more than an hour. Long after it was half way it would keep turning round and trying to come back to the ship. I cannot describe to you the excitement there was on board. I fairly cried once with anxiety and excitement, it would have been too horrible to see it drowned! It tried to climb up the ship's side once. It was pouring with rain, which made things seem more dismal; we were all wet through, but nobody cared. We had to get our experience as we went on, as no one knew anything about elephants on landing. We managed the other three much better, and made the Captain take the ship nearer in shore. Capt. Carter has stayed over there to take the elephants to Dar-es-Salaam, a distance of four miles, and will stay to see them comfortably settled."

THE *Novoye Vremya* gives some further news as to the progress of the Russian traveller, Col. Prjevalsky. The distance from the Saisan port to the River Buguluk, in the southern Altai mountains, was accomplished by the Colonel towards the end of April. All this tract is a barren desert, having neither flora nor fauna, though the banks of the River Urungu were found to bear some slight vestiges of vegetation. As for the climate, Col. Prjevalsky describes it as characterised by frost at night-time, with heat and storms during the day. Eight degrees of frost in the morning were often followed by 20 deg. of

heat at noon. Nevertheless, the scientific labours of the expedition had great success, the country being explored in all directions, and the gallant Colonel only hopes to attain as fruitful results in Thibet. He intended advancing to Barkul and Chami, as the shortest way through the southern Altai range.

FROM the Annual Report upon the Survey of the Northern and North-Western Lakes and the Mississippi River, in charge of Major C. B. Comstock and Capt. H. M. Adams, we learn that on Lake Erie the triangulation has been carried from Cleveland, Ohio, to the west end of the lake. The topography and hydrography have been extended to include all of the American shore, and the Canadian shore from Detroit River to Point Pelée. A base-line has been measured near Chicago and the connecting triangulation east has been completed to White Pigeon, Mich. The latitude and longitude of Memphis, Tenn., have been determined, and in connection with Capt. W. S. Stanton, United States Engineers, the longitudes of Fort Laramie, Wyo., Camp Robinson, Neb., and Deadwood, Dak., have been determined. The survey of the Mississippi River has been carried from Mound City, above Memphis, to Scanlon's Landing, Ark., and a line of precise levels has been completed from Memphis, Tenn., to Austin, Miss. A chart of Lake Ontario, coast charts Nos. 1 and 2 Lake Ontario, coast charts Nos. 7, 8, and 9 Lake Michigan, and detail charts Nos. 1, 2, 3, 4, 5, 6, and 7 Mississippi River have been completed.

IN his last report from Saigon, Mr. Consul Tremlett states that the water communication between Saigon, Cholon, and the western provinces of French Cochin China being very circuitous and inadequate to the traffic, the Canal of Cho-goo has been cut from Cho-goo to Soug-tra, being six miles in length and 110 feet broad. This canal is of immense importance to the country between the River Donnai and the Mei-Kong. Another short canal is to be cut near the junction of the Viaco and Soir-ap, two arms of the Donnai. Mr. Tremlett also mentions that a canal which did not attract much attention was opened in 1876, connecting the lower and upper branches of the Mei-Kong; it is 3½ miles long, and opens a more direct course from the south-western parts of the colony to Cholon, the great centre of traffic.

ERNEST MARNO, the well-known Austrian traveller in Africa, who originally formed one of the staff of the Belgian expedition under the late Capt. Crespel, has recently been appointed deputy governor of the province of Galabat in the Soudan. M. Statin, another Austrian traveller, has gone to the region of the Upper Nile, the special object of his journey being meteorological investigations.

MESSRS. S. T. LEIGH AND CO., of Sydney, have issued a map which will be very useful to persons visiting Australia during the approaching exhibition. It shows the Great Western Railway of New South Wales crossing the Blue Mountains, from the Nepean River to Bowenfels, also the localities and natural features of greatest general interest. The map has been compiled on the scale of one geographical mile to an inch by Mr. E. Du Faur, and is intended to accompany some fine photographs of the same region which Mr. Du Faur published about two years back. The more remarkable gorges and cliffs among the mountains are illustrated by dark shading.

NO. 1 of the new volume (36) of *Globus* has the first of a series of articles on the Island of Chios, by Dr. Ad. Testevuide, of that island. There are two papers of considerable ethnological interest: one by M. Andrée on the ethnological boundaries in France, and the other by Dr. Jung, mentioned in next note, on Australian types and sketches. Among the news are some details concerning Severtzov's second journey in the Pamir.

"AUSTRALIEN UND NEUSEELAND" is the title of an historical, geographical, and statistical sketch by Dr. Carl E. Jung, which has just been published at Leipzig (O. Mutze), with ten illustrations.

LAST YEAR'S SOLAR ECLIPSE[1]

WE have received an interesting account of the observations made during the late eclipse in Texas, under the direction of Mr. Waldo. The first part of the Report is chiefly taken up with an account of the determination of the geographical position of Fort Worth. The second part contains the reports of the various observers. Mr. Waldo gives a description of the photographs obtained. Unfortunately the camera had no proper clockwork. An ingenious, though most likely shaky, arrangement was used to correct the sun's motion in altitude, while his motion in azimuth was left to take care of itself. Each point more luminous than the remainder of the sun's corona is therefore drawn out into a line; but this outline of the moon's edge at the beginning and end of totality is sufficient to determine the position of these brighter points. An attempt was made to obtain photographic evidence of the polarisation of the corona, by inserting a double image prism between the lenses of the camera. The result was doubtful. The photographs were examined by Prof. Pickering, who found inequalities in them, which, as far as they go, tend to indicate a tangential polarisation; but in the opinion of Dr. Hastings, the evidence is not conclusive.

Mr. R. W. Willson observed the corona through a 3-inch telescope. By an oversight a red shade was not removed before totality. Through this shade the corona seemed to have a pretty well-defined limit about four or five minutes from the moon's limb. After the shade had been removed, other portions of the corona could be seen, the light of which was nearly as intense as that near the sun's limb; while the ring, which alone was visible through the shade, was not distinguished from the other parts of the corona. These observations would indicate that there is more red light in the corona near the body of the sun than away from it; and this observation is confirmed by Prof. S. H. Lockett, who, in a letter to Mr. Waldo, calls the outer corona "more bluish-white" than the inner corona.

Prof. J. H. Rees made some spectroscopic observations with a two-prism spectroscope. No bright lines were seen; but on widening the slit dark lines were noticed, amongst them especially C and D.

Mr. W. H. Pulsifer made also some spectroscopic observations. He noticed the reversal of the Fraunhofer lines with a tangential slit, and from the length of these lines he determined approximately the thickness of the reversing layer to be about 524 miles. No observations could be made during totality, as the image of the corona on the slit was lost, and could not be found again. The mischief was caused originally by one of the lamps, which went out just before totality. Moral: Don't trust to any lamps during eclipse observations. There is always a gust of wind at the beginning of totality, which is pretty sure to extinguish lamps.

Mr. Seagrave could see the inner corona about thirty seconds before totality.

Several gentlemen have sent in sketches of the corona, which are given on the last of the four plates accompanying the report. The remaining plates are taken up by an enlarged copy of the best photograph obtained, by a sketch illustrating Mr. Willson's report, and by a sketch of the corona made by Prof. Lockett.

ARTHUR SCHUSTER

[1] Report of the Observations of the Total Solar Eclipse, July 29, 1878, made at Fort Worth, Texas. Edited by L. Waldo. (Cambridge: J. Wilson and Son, 1879.)

MOLECULAR PHYSICS IN HIGH VACUA[1]

WHEN I was asked, a month or two ago, to illustrate in this theatre some of my recent researches on molecular physics in high vacua, I exclaimed, "How is it possible to bring such a subject worthily before a Royal Institution audience when none of the experiments can be seen more than three feet off?" If to-night I am fortunate enough to show all the experiments to those who are not far distant, and if I succeed in making most of them visible at the far end of the theatre, such a success will be entirely due to the great kindness of your late secretary, Mr. Spottiswoode, who has placed at my disposal his magnificent induction-coil—not only for this lecture, but for some weeks past in my own laboratory—thus enabling me to prepare apparatus and vacuum tubes on a scale so large as to relieve me of all anxiety so far as the experimental illustrations are concerned.

Before describing the special researches in molecular physics which I propose to illustrate this evening, it is necessary to give a brief outline of one small department of the modern theory of the constitution of gases. It is not easy to make clear the kinetic theory, but I will try to simplify it in this way:—Imagine that I have in a large box a swarm of bees, each bee independent of its fellow, flying about in all manner of directions and with very different velocities. The bees are so crowded that they can only fly a very short distance without coming into contact with one another or with the sides of the box. As they are constantly in collision, so they rebound from each other with altered velocities and in different directions, and when these collisions take place against the sides of the box pressure is produced. If I take some of the bees out of the box, the distance which each individual bee will be able to fly before it comes into contact with its neighbour will be greater than when the box was full of bees; and if I remove a great many of the bees I increase to a considerable extent the average distance that each can fly without a collision. This distance I will call the bee's *mean free path*. When the bees are numerous the mean free path is very short; when the bees are few the mean free path will be longer, the length being inversely proportional to the number of bees present. Let us now imagine a loose diaphragm to be introduced in the centre of the box, so as to divide the number of bees equally. The same number of bees being on each side, the impacts on the diaphragm will be equal; and the mean speed of the bees being the same, the pressure will be identical on each side of the diaphragm, and it will not move.

Let me now warm one side of this division so as to let it communicate extra energy to a bee when it touches it. As before, a bee will strike the diaphragm with its normal mean velocity, but will be driven back with extra velocity, the reaction producing an increase of pressure on the diaphragm. It will be found, however, that although the diaphragm is free to move, the extra strength of the recoil on the warm side does not produce any motion. This at first sight seems contrary to the law of action and reaction being equal. The explanation is not difficult to understand. The bees which fly away from the diaphragm have drawn energy from it, and therefore move quicker than those which are coming towards it; they beat back the crowd to a greater distance, and keep a greater number from striking the diaphragm. Near to the heated side of the diaphragm the density is less than the average, while beyond the free path the density is above the average, and this greater crowding extends to all other parts of the box. Thus it happens that the extra energy of the impacts against the warm side of the diaphragm is exactly compensated by the increased number of impacts on the cool side. In spite therefore of the increased activity communicated to a portion of the bees, the pressure on the two sides of the diaphragm will remain the same. This represents what occurs when the extent of the box containing the bees is so great, compared with the mean free path, that the abrupt change in the velocities of those bees which rebound from the walls of the box produces only an insensible influence on the motions of bees at so great a distance as the diaphragm.

I will next ask you to imagine that I am gradually removing bees from our box, still keeping the diaphragm warm on one side. The bees getting fewer the collisions will become less frequent, and the distance each bee can fly before striking its neighbour will get longer and longer, and the crowding in front of them will grow less and less. The compensation will also diminish, and the warmed side of the diaphragm will have a tendency to be beaten back. A point will at last be reached on the warm side, when the mean free path of the bees will be long enough to admit of their dashing right across from the diaphragm to the side of the box, without meeting more than a certain number of in-coming bees in their flight. In this case the bees will no longer fly quite in the same direction as before. They will now fly less sideways, and more forwards and backwards between the heated face of the diaphragm and the opposed wall of the box. Because of this preponderating motion, and also because they will thereby less effectually keep back bees crowding in from the sides, there will now be a greater proportionate pressure both on the hot face of the diaphragm and on that part of the box which is in front of it. Hence the pressure on the hot side will now exceed that on the cool side of the diaphragm, which will consequently have a backward movement communicated to it.

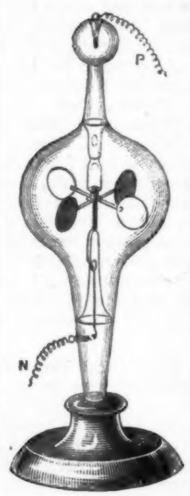


FIG. 1.

I may diminish the size of the bees as much as I like, and by correspondingly increasing their number the mean free path will remain the same. Instead of bees let me call them molecules, and instead of having a few hundreds or thousands in the box let me have millions and billions and trillions; and if we also diminish the mean free path to a considerable extent, we get a rough outline of the kinetic theory of gases. (I may just mention that the mean free path of the molecules in air, at the ordinary pressure, is the ten-thousandth of a millimetre.)

Three years ago I had the honour of bringing before you the results of some researches on the radiometer. Let me now take up the subject where I then left off. I have here two radiometers which have been rotating before you under the influence of a strong light shining upon them.

The explanation of the movement of the radiometer is this—the light, or the total bundle of rays included in the term "light," falling upon the blackened side of the vanes, becomes absorbed, and thereby raises the temperature of the black side: this causes extra excitement of the air molecules which come in contact with it, and pressure is produced, causing the fly of the radiometer to turn round.

I have long believed that a well-known appearance observed in vacuum tubes is closely related to the phenomena of the mean free path of the molecules. When the negative pole is examined while the discharge from an induction coil is passing through an exhausted tube, a dark space is seen to surround it. This dark space is found to increase and diminish as the vacuum is varied, in the same way that the ideal layer of molecular pressure in the radiometer increases and diminishes. As the one is perceived by the mind's eye to get greater, so the other is seen by the bodily eye to increase in size. If the vacuum is insufficient to permit the radiometer to turn, the passage of electricity shows

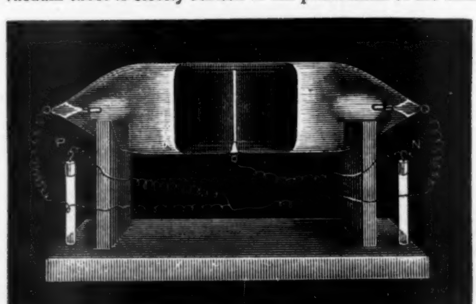


FIG. 2.

[1] A short-hand report of a lecture delivered at the Royal Institution on Friday, April 4, 1879. By William Crookes, F.R.S. Contributed by the author.

that the "dark space" has shrunk to small dimensions. It is a natural inference that the dark space is the mean free path of the molecules of the residual gas.

The radiometer which has just been turning under the influence of the lime-light is not of the ordinary kind. Fig. 1 will explain its construction.

It is similar to an ordinary radiometer with aluminium disks for vanes, each disk coated on one side with a film of mica. The fly is supported by a hard steel instead of glass cup, and the needle point on which it works is connected by means of a wire with a platinum terminal sealed into the glass. At the top of the radiometer bulb a second terminal is sealed in. The radiometer can therefore be connected with an induction-coil, the movable fly being made the negative pole.

As soon as the pressure is reduced to a few millims. of mercury, a halo of velvety violet light forms on the metallic side of the vanes, the mica side remaining dark. As the pressure diminishes, a dark space is seen to separate the violet halo from the metal. At a pressure of half a millim. this dark space extends to the glass, and positive rotation commences. On continuing the exhaustion the dark space further widens out and appears to flatten itself against the glass, when the rotation becomes very rapid.

You perceive a dark space behind each vane and moving round with it. In the first experiment, radiation from the lime-light falling on the metallic sides of the vanes, produced a layer of molecular pressure which drove the fly round; so here the induction-current has produced molecular excitement at the surface of the vanes forming the negative pole, extending up to the side of the glass.

When the negative pole is in rapid rotation it is not easy to see this dark space, so I have arranged a tube in which the dark space will be visible to all present. The tube, as you will see by the diagram (Fig. 2), has a pole in the centre in the form of a metal disk, and other poles at each end. The centre pole is made negative, and the two end poles connected together are made the positive terminal. The dark space will be in the centre. When the exhaustion is not very great the dark space extends only a little distance on each side of the negative pole in the centre. When the exhaustion is very good, as it is in the tube before you, and I turn on the coil, the dark space is seen to extend for about two inches on each side of the pole.

Here, then, we see the induction spark actually illuminating the lines of molecular pressure caused by the excitement of the negative pole. The thickness of this dark space—nearly two inches—is the measure of the mean free path between successive collisions of the molecules of the residual gas. The extra velocity with which the negatively electrified molecules rebound from the excited pole keeps back the more slowly moving molecules which are advancing towards that pole. The conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the discharge.

I will endeavour to throw on the screen an illustration of this dark space. A stream of water falls from a small jet on to a horizontal plate of glass. The water spreads over the plate and forms a thin film. The jet of water in the centre, from the velocity of its fall, drives the film of water before it on all sides, raising it into a ring-shaped heap. As I diminish the force of the jet the ring contracts; this is equivalent to the exhaustion getting less. When I increase the force of water the ring expands in size, the effect being analogous to an increase of exhaustion in my tubes. The extra velocity of the falling particles of water drives the in-coming particles of water before them, and raises a ridge round the side which exactly represents the luminous halo to the dark space to be seen in this tube.

If, instead of a flat disk, a metal cup is used for the negative pole, the successive appearances on exhausting the tube are somewhat different. The velvety violet halo forms over each side of the cup. On increasing the exhaustion the dark space widens out, retaining almost exactly the shape of the cup. The bright margin of the dark space becomes concentrated at the concave side of the cup to a luminous focus, and widens out at the convex side. When the dark space is very much larger than the cup, its outline forms an irregular ellipsoid drawn in towards the focal point. Inside the luminous boundary a dark violet light can be seen converging to a focus, and, as the rays diverge on the other side of the focus, spreading beyond the margin of the dark space; the whole appearance being strikingly similar to the rays of the sun reflected from a concave mirror through a foggy atmosphere. This proves a somewhat important point; it shows that the molecules thrown off the excited negative pole leave it in a direction almost normal to the surface.

I can illustrate this property of the molecular rays by an experiment. This diagram (Fig. 3) is a representation of the tube which is before you. It contains, as a negative pole, a hemi-cylinder (*a*) of polished aluminium. This is connected with a fine copper wire, *b*, ending at the platinum terminal, *c*.

FIG. 3.

At the upper end of the tube is another terminal, *d*. The induction-coil is connected so that the hemi-cylinder is negative and the upper pole positive, and when exhausted to a sufficient extent, as is the case with this tube, the projection of the molecular rays to a focus is very beautifully shown. The rays are driven from the hemi-cylinder in a direction normal to its surface; they come to a focus and then diverge, tracing their path in brilliant green phosphorescence on the surface of the glass.

You will notice that the rays which project from the negative pole and cross in the centre have a bright green appearance; that colour is entirely due to the phosphorescence of the glass. At a very high exhaustion the phenomena noticed in ordinary vacuum tubes when the induction spark passes through them—an appearance of cloudy luminosity and of stratifications—disappears entirely. No cloud or fog whatever is seen in the body of the tube, and with such a vacuum as I am working with in these experiments—about a millionth part of an atmosphere—the inner surface of the glass glows with a rich green phosphorescence, the intensity of colour varying with the perfection of the vacuum. It scarcely begins to show much before the 800,000th of an atmosphere. At about a millionth of an atmosphere the phosphorescence is very strong, and after that it begins to diminish

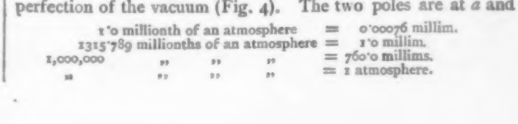


FIG. 4.

until there are not enough molecules left to allow the spark to pass.[1]

I have here a tube which will serve to illustrate the dependence of the green phosphorescence of the glass on the degree of perfection of the vacuum (Fig. 4). The two poles are at *a* and

[1]
1·0 millionth of an atmosphere	= 0·00076 millim.
1315·789 millionths of an atmosphere	= 1·0 millim.
1,000,000 " " "	= 760·0 millims.
" " " "	= 1 atmosphere.

b, and at the end (*c*) is a small supplementary tube connected with the other by a narrow aperture, and containing solid caustic potash. The tube has been exhausted to a very high point, and the potash heated so as to drive off moisture and deteriorate the

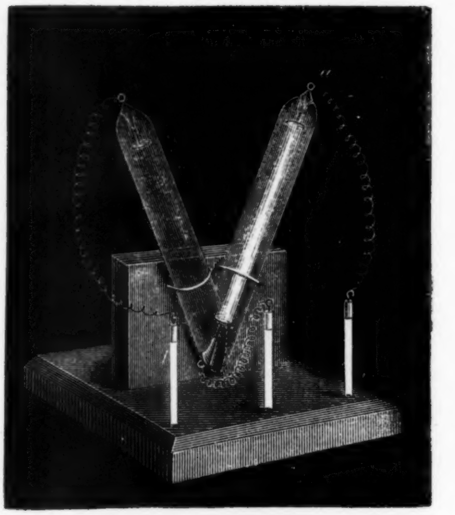


FIG. 5.

vacuum. Exhaustion has then been re-commenced, and the alternate heating and exhaustion have been repeated until the tube has been brought to the state in which it now appears before you. When the induction spark is first turned on nothing is visible—the vacuum is so high that the tube is non-conducting. I now warm the potash slightly, and liberate a trace of aqueous vapour. Instantly conduction commences, and the green phosphorescence flashes out along the length of the tube. I continue the heat, so as to drive off more gas from the potash. The green gets fainter, and now a wave of cloudy luminosity sweeps over the tube, and stratifications appear. These rapidly get narrower, until the spark passes along the tube in the form of a narrow purple line. I take the lamp away, and allow the potash to cool; as it cools, the aqueous vapour, which the heat had driven off, is re-absorbed. The purple line broadens out, and breaks up into fine stratifications; these get wider, and travel towards the potash tube. Now a wave of green light appears on the glass at the other end, sweeping on and driving the last pale stratification into the potash; and now the tube glows over its whole length with the green phosphorescence. Would time allow I might keep it before you, and show the green growing fainter and the vacuum becoming non-conducting; but time is required for the absorption of the last traces of vapour by the potash, and I must pass on to the next subject.

This green phosphorescence is a subject that has much occupied my thoughts, and I have striven to ascertain some of the laws governing its occurrence. I soon perceived that the phosphorescence was not in the body of the tube itself, but was entirely on the surface of the glass. Another peculiarity of the rays producing this green phosphorescence is that they will not turn a corner in the slightest degree. Here is a V-shaped tube (Fig. 5), a pole being at each extremity. The pole at the right side (*a*) being negative, you see that the whole of the right arm is flooded with green light, but at the bottom it stops sharply, and will not turn the corner to get into the left side. When I reverse the current, and make the left pole negative, the green changes to the left side, always following the negative pole, leaving the positive side with scarcely any luminosity.

In the ordinary phenomena exhibited by vacuum tubes—phenomena with which we are all familiar—it is customary, for the more striking illustration of their contrasts of colour, to have the tubes bent into very elaborate designs. The positive luminosity caused by the phosphorescence of the residual gas follows all the convolutions and designs into which skilful glass-blowers

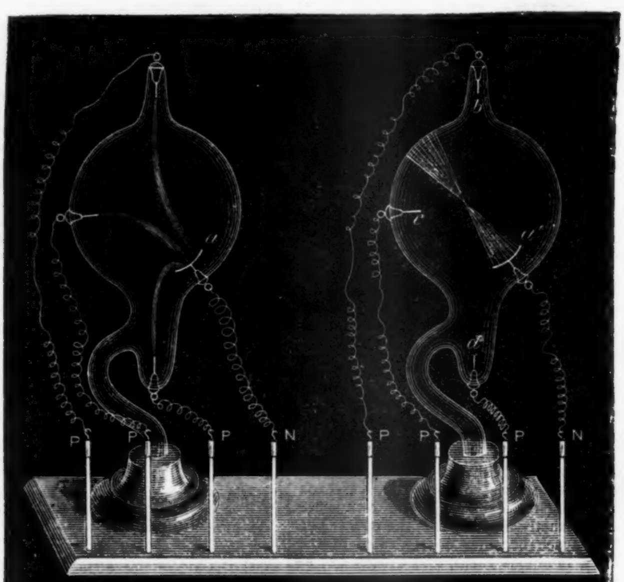


FIG. 6.

can manage to twist the glass. The negative pole being at one end and the positive pole at the other, the luminous phenomena seem to depend more on the positive than on the negative at an ordinary exhaustion such as has hitherto been used to get the best phenomena of vacuum tubes. I have here two bulbs (Fig. 6), alike in shape and position of poles, the only difference being that one is at an exhaustion equal to a few millimetres of mercury —such a moderate exhaustion as will give stratifications or the

ordinary luminous phenomena—whilst the other is exhausted to about the millionth of an atmosphere. I will first connect the moderately exhausted bulb with the induction-coil, and, retaining the pole at one side (*a*) always negative, I will put the positive wire successively to the other three poles with which the bulb is furnished. You will see that as I change the position of the positive pole, the line of violet light joining the two poles changes. In this moderately exhausted bulb, therefore, the electric current always chooses the shortest path between the two poles, and moves about the bulb as I alter the position of the wires.

This, then, is the kind of phenomenon we get in ordinary exhaustions. I will now try the same experiment with a tube that is highly exhausted, and, as before, will make the side pole (*a'*) the negative, the top pole (*b*) being positive. Notice how widely different is the appearance from that shown by the last bulb. The negative pole is in the form of a shallow cup. The bundle of rays from the cup crosses in the centre of the bulb, and thence diverging, falls on the opposite side as a circular patch of green light. As I turn the bulb round you will all be able to see the faint blue focus and the green patch on the glass. Now observe, I remove the positive wire from the top, and connect it with the side pole (*c*). The green patch from the divergent negative focus is still there. I now make the lowest pole (*d*) positive, and the green patch still remains where it was at first, unchanged in position or intensity.

This, then, gives us another fact which brings us a little nearer to the cause of this green phosphorescence. It is this—that in the low vacuum the position of the positive pole is of every importance, whilst in a high vacuum it scarcely matters at all where the positive pole is; the phenomena seem to depend entirely on the negative pole. In very high vacua, such as we have been using, the phenomena follow altogether the negative pole. If the negative pole points in the direction of the positive, all very well, but if the negative pole is entirely in the opposite direction it does not matter; the line of rays is projected all the same in a straight line from the negative.

(*To be continued.*)

NOTES

THE following grants have just been made from the Research Fund of the Chemical Society:—30*l.* to Mr. W. Whitley Williams for experiments on an improved method of organic analysis; 25*l.* to Mr. M. M. Pattison Muir, of Caius College, Cambridge, for determining the physical constants and chemical habitudes of certain bismuth compounds; 15*l.* to Mr. J. M. Thomson for experiments on the action of isomorphous bodies in exciting the crystallisation of super-saturated solutions; 50*l.* to Dr. Wright for continuing his researches on chemical dynamics; 25*l.* to Mr. F. D. Brown for continuing his researches on the theory of fractional distillation; 30*l.* to Mr. Bolas for an investigation of certain chromium compounds; 20*l.* to Mr. F. R. Japp for an investigation of the action of organo-zinc compounds on quinones; and 100*l.* (the De la Rue donation) to Dr. H. E. Armstrong for the determination of certain physical properties, especially refractive indices, of typical chemical compounds. Dr. De la Rue has announced his intention of presenting the fund with another 100*l.* This will be the third donation of that amount which the fund has received from him.

THE Council of the Royal Society of Edinburgh have decided to award the Makdougall Brisbane Prize for the biennial period 1877-78 to Prof. Geikie for his "Memoir on the Old Red Sandstone of Western Europe," Part I., published in the Society's *Transactions*, and forming part of his valuable contributions to geology.

GENERAL MYER, of the U.S. Signal Corps, has arrived in Paris from Rome, on his way to London, where he will have an interview with the Meteorological Board for the purpose of establishing an understanding in matters of common interest, especially on the subject of exchanging telegrams with America, so that both nations may enjoy a daily summary of the weather on each continent.

M. LISSAJOUS has been elected a Foreign Corresponding Member in the Paris Academy, Section of Physics, in place of the late Dr. von Mayer.

DR. FAIVRE, the Dean of the Lyons Faculty of Sciences, has been run over by a cart when conducting a number of pupils to a botanical excursion. His constitution was so dreadfully shaken that he died after a few days of suffering. Dr. Faivre was opposed to the Darwinian theory, and has published books against the mutation of species. His most important publication was a review of Goethe's scientific works.

THE collection of living reptiles in the Jardin des Plantes, Paris, has just received an interesting addition in the shape of three living examples of the rare East-Indian serpent known to naturalists as *Acrochordus javanicus*. These snakes belong to quite a peculiar type of the Ophidian order, and are, in fact, truly fresh-water snakes, living among rocks wholly immersed beneath the surface, and but seldom rising up to inhale air. They are quite harmless, and allow themselves to be handled without difficulty. The food of the *Acrochordus* is supposed to be fruit—a most anomalous diet for a snake, if this is really the case, but the specimens at Paris have not yet shown a taste for eating anything.

WITH reference to a recent note, the Abbé Moigno writes us from Rome that he has not resigned the editorship of *Les Mondes*, which he has edited for twenty-seven years. He has gone to Rome to lay at the feet of the Pontiff the results of many years laborious work, but will return as he went, not a Cardinal, but the *doyen* of scientific journalists, eager for progress in all directions. We sincerely wish the Abbé many more years to carry on the work of editing his well-known journal, that has for so long done good service to science.

AMONG other recommendations made at the recent meeting of the International Meteorological Congress was the adoption of the meridian of Greenwich as the starting-point for the construction of synoptic weather charts. In the event of another meridian being used in the construction of meteorological charts the Congress recommended that the difference of longitude between the meridian employed and that of Greenwich should be stated on the chart.

A TERRIFIC thunderstorm broke over Paris on June 28 at six o'clock in the morning. There were a number of casualties; one of the most singular occurred in a room in the rue de Clichy, No. 34, where two old ladies live. One of them was drinking milk from a cup, which was knocked from her hands and could not be found, although the lady escaped unhurt. In the *rez-de chaussée* was the shop of a chemist, where a number of bottles were broken, and in the same house a bed, where a woman had taken refuge, was cut into two equal parts.

IN a balloon ascent which took place at Rouen on June 15 last with a large balloon, the occupants of the car found at 12,000 metres from the earth a cloud where the cold was so intense that small icicles were seen suspended to the beards and moustaches of the travellers.

THE Parkes Museum of Hygiene, founded as a memorial of the late Dr. E. A. Parkes to promote the study of all matters bearing upon the health of the community or the individual, was formally opened on Saturday by the Home Secretary, in the rooms on the top floor of the building lent by the council of University College until separate and suitable premises can be obtained. At present there have been brought together apparatus, specimens, books, reports, and drawings illustrative of matters connected with engineering and local hygiene; architecture, including general designs and details of buildings, methods of constructing hospitals, blocks of artisans' dwellings, &c., with

specimens of appliances for necessary sanitary arrangements, drainage, ventilation, and lighting; the furnishing of buildings, public and domestic, clothing, food; and the preservation of health and the relief of sickness. At present the collection is incomplete, but the committee hoped that funds and material would be forthcoming to make the Parkes Museum a national and a useful institution worthy of the important subject which it illustrated and the great name it bore. Prof. Huxley, who was present, expressed a hope that Mr. Cross would use his influence with the Government and with the House of Commons to stay a movement which appeared intended to dam back the stream of education and prevent the lower classes from gaining the knowledge they so much needed.

A MEETING of ladies and gentlemen interested in Japanese art, literature, folk-lore, &c., will be held to-morrow at the Royal Asiatic Society, 22, Albemarle Street. The meeting is called together for the purpose of establishing in London a central institution, with the following objects:—To bring into closer communication admirers and students of Japanese art, literature, &c.; and to collect, record, and disseminate information relative to Japan. To encourage residents in Japan, and the Japanese, to collect such material. To enlist the cordial co-operation of scientific and literary societies, and individuals, in extending the usefulness of the Institution. To publish proceedings, notes, queries, and other interesting matter; and to facilitate this branch of research and study. After the business is concluded, an "Old Resident" will communicate some interesting facts about Japan, illustrated by photos, &c., from his collection, and discussion will follow.

SOME attention has recently been drawn in the *Gardeners' Chronicle* to tea prepared in St. Michael, Azores, from plants grown in that island. It seems that two Chinese tea-growers have been sent for by the Agricultural Society of St. Michael, and after a careful examination of the tea-plantations they pronounced the plants as belonging to the very best varieties grown in China. It is prophesied that "the time is not far off when tea from St. Michael will come to the European market and prove to be of a very good quality." In a subsequent number of the *Gardeners' Chronicle*, however, Mr. Elwes points out the difficulties to be contended with in a competition with India and China in the production of tea, notably the price of land, the cost of labour, the temperature, extent of rainfall, &c. The first outcome of this tea growing in the Azores is shown in a sample recently received at the Kew Museum from Señor José de Canto. This sample is of good appearance through perhaps somewhat over roasted, the smell also is good, and the flavour of the infusion by no means to be despised.

THE new fodder grass *Euchlæna luxurians* known as the Teosinte, and which has attracted considerable attention of late, is reported from Ceylon as growing well, having been introduced from Java. The stems have attained in the former island the height of eight feet in three months from the time of sowing. The plant is stated to be unsuitable for cultivation at high elevations, but it is hoped that after a time it would become acclimatised to them. At the time the above was written the seeds were being distributed in several districts.

DR. SCHOMBURGK in his "Report on the Progress and Condition of the Botanic Garden and Government Plantations" of Adelaide, South Australia, for the year 1878, gives, as usual, a great deal of consideration to plants of economic interest. In the experimental ground many of the well-known British fodder grasses have been grown and produced satisfactory results. Dr. Schomburgk, however, points out the almost impossibility of stocking runs with artificial grasses on account of the large extent of pastoral land, and of the insuperable difficulty arising from climate and drought, to which some parts of the colony, especially the north, are often subjected. *Euchlæna luxurians* has not been introduced long enough to give any practical results. It is hoped, however, that the plant will turn out a great acquisition to the summer fodder plants of Australia. On the subject of flower farming for perfumery purposes there is no doubt that the Australian colonies offer special advantages for this branch of culture. Dr. Schomburgk thinks favourably of the scheme, but considers it unadvisable to manufacture the scents in the colony on account of the greater perfection with which this kind of work is done at home. As an illustration of the importance of this single use of flowers Dr. Schomburgk says:—If we consider that British India and Europe consume about 150,000 gallons of handkerchief perfume yearly, and the English revenue from Eau-de-Cologne alone is about 8,000*l*. a year; that the total revenue from imported perfumes is estimated at about 40,000*l*., and that one great perfume distillery at Cannes in France uses yearly about 100,000 lbs. of Acacia flowers (*Acacia farnesiana*), 140,000 lbs. of rose-flower leaves, 32,000 lbs. of jasmine blossoms, 20,000 lbs. of tuberose, together with a great many other sweet herbs, we may judge of the immense quantity of material used for perfume. It is satisfactory to find that the Colonial Parliament has granted a sum of 1,000*l*. towards the erection of a new building for the Museum of Economic Botany; this sum, however, it is expected, will be supplemented by a further vote, so that a building of sufficient size, to meet the requirements of the next generation, may be erected. The design, as already furnished, is for a building in the Romanesque style, 100 feet long by 36½ feet wide. The show cases will be fixed between the windows and at right angles with them on the plan adopted in the New Museum at South Kensington. From the promises of specimens, together with those already contained in the present museum, amounting to about 2,000 objects, it is expected that the museum when finished will form a very important adjunct to the gardens. The Report concludes with a notice of the *Phylloxera vastatrix*, or vine disease, which is enlarging its borders so much as to threaten a serious visitation in Australia.

SEVERAL remarkable results have been recently obtained by Herr Kohlrausch in his researches on the electric conductivity of aqueous solutions (*Annalen der Physik*), and especially with regard to the influence of temperature on the conducting power of liquids. Thus concentrated soda-lye, which, at a temperature of $-10°$ conducts badly, acquires, under action of heat, a conducting power which increases regularly and with very great rapidity, so that at $+80°$ the liquid conducts a *hundred* times better than at $-10°$. A solution of bisulphate of potash behaves quite differently; its conducting power increases very slowly with the temperature, up to a temperature of 60°, at which there is a maximum. From this point the conductivity remains nearly constant, as the temperature is raised. Studying solutions of sulphate of soda, which are known to present at 33° a remarkable peculiarity, due to the proportion, more or less, of water of crystallisation, Herr Kohlrausch found nothing peculiar in the conducting power. This seems to prove that water of crystallisation does not play any part in the conductivity of liquids for electricity.

IN addition to his astronomical paper, Admiral Mouchez is preparing the organisation, at the Observatory, of a High School of Astronomy composed of pupils from the Polytechnic and Normal Schools, and licenciés en sciences, mathematiques, et physiques. The salary of successful pupils will be 1,800 francs a year, and positions will be secured for them in the French national observatories. The school will also admit a number of free students, who will have the advantage of the use of the instruments of the observatory.

THE New York correspondent of the *Daily News* telegraphs as follows:—"Mr. Edison has obtained a dynamometer of suffi-

cient delicacy to measure every one-hundredth of horse-power. With this instrument he can calculate the cost of the electric light to the minutest detail. He has demonstrated that from 80 to 90 per cent. of energy is converted into light, and that six electric lights are supplied from one horse-power at one-third the cost of gas. He maintains that the problem of applying the electric light to domestic use has been practically solved, but admits that a great mass of detail remains to be worked out. He has satisfied himself that platinum can be supplied in large quantities so as to reduce the expense.

THE forests of Central Nevada appear (from the accounts of Mr. Sargent, who visited the region last year, and writes about them in *Silliman's Journal* for June) to be miserably poor in extent, productiveness, and especially in number of species. Yet they are of immense value, as regulating and protecting the rare and uncertain streams on which the agriculture of Nevada depends, and furnishing a large population with fuel and lumber, a population practically cut off from outside supply. Mr. Sargent laments the wasteful destruction of forest which follows every new discovery of the precious metals in that region, both on account of the immense age of these forests, and of the impossibility of restoration; and he thinks government should check it. The central Nevada forests consist of but seven species, the juniper (*Juniperus californica*, var. Utahensis) and nut pine (*Pinus monophylla*, Torr.), being the most common. Mountain mahogany (*Cercocarpus ledifolius*) comes next, probably the only North American wood heavier than water, and furnishing the common and cheapest fuel. The other species are the red cedar, the aspen, and two of pine. A comparison which Mr. Sargent makes, of the arborescent vegetation of Nevada with that of the region lying directly east and west of the Great Basin, brings out still more clearly the remarkable poverty of the former.

A VERY ingenious application of electricity to the purposes of navigation has recently been effected by Mr. Henry A. Severn, of Herne Hill, who has succeeded in producing a mariner's compass which enables the captain or officer in charge to hear, by the ringing of a bell, when the vessel is out of the ordered course. The whole of the apparatus is contained in a small box which is easily carried about, and is intended, as a rule, to be placed in the captain's cabin. Over the card are two index hands, which can be adjusted to any angle allowing of greater or less deviation in steering to either the port or starboard side. Assuming the captain, on quitting the deck, to have given instructions to steer the ship on a certain course, he sets the index hands to a certain angle, allowing the steersman a given latitude for deviation either to port or starboard of that course. Should the ship be steered off her course beyond the limit allowed on either side an electric alarm-bell rings instantaneously and, moreover, continues ringing until the right course is resumed. The metal point on which the card is hung is insulated from the compass bowl, and to it is attached a wire from one pole of a small battery. About an inch above the card, placed parallel to its surface and attached to its metal centre (which is insulated from the needle) is an arm of metal reaching nearly to the edge of the card. This arm is, therefore, in metallic communication with the wire from the battery already referred to. The glass lid of the compass has a short brass rod working within a tube passing through it. These are severally attached to two brass milled heads above the glass lid and to the two movable index-hands beneath the glass. These are in metallic contact with the brass-work of the compass, and this with the other pole of the battery. Beneath the outer extremities of the index-hands are suspended two pieces of platinum wire about three-quarters of an inch long. These hands can, by means of the two milled heads, be moved round to any position over any point of the card. Hence they admit of being placed on either side and equally distant or otherwise from the end of the metal arm on the card. It will thus be seen that whenever the platinum wires come into contact with the metal arm on the card the circuit is completed. The electric bell being placed in the circuit sounds whenever such contact takes place. Two bells of different tone can be used, and thus the instrument will indicate to the captain whether the deviation in steering is to port or starboard.

WE have received an interesting *Jahresbericht* of the Natural History Society of Wisconsin, which is evidently largely composed of Germans, the Report being in that language.

WE have on our table the following books:—"The Human Species," A. de Quatrefages (C. Kegan Paul); "Practical Photography," Part 1, O. E. Wheeler (*Bazaar* Office); "Modern Meteorology" (Ed. Stanford); "Mechanics," Prof. R. S. Ball (Longmans); "The Application of Generalised Co-ordinates to the Kinetics of a Material System," H. W. Watson and S. H. Burbury (Clarendon Press); "Galileo Galilei," Karl von Gebler (Kegan Paul); "What is Truth," John Coutts (F. Pitmann); "Sulphuric Acid and Alkali," Vol. i., George Lunge (Van Voorst); "Elementary Arithmetic and How to Teach It," G. Ricks (Isbister and Co.); "Supplement to a Handbook of Chemical Manipulation," C. G. Williams (Van Voorst); "Town and Window Gardening," C. M. Buckton (Longmans); "Der Process Galilei's und die Jesuiten," Dr. F. H. Reusch (Edw. Weber, Bonn); "Parasites, a Treatise on the Entozoa of Man and Animals," T. Spencer Cobbold, M.D. (Churchill); "Elements of South-Indian Palæography," A. C. Burnett (Trübner); "Twenty Lessons in Inorganic Chemistry," W. G. Valentine (W. Collins); "Observed Lunar Distances," John B. Pearson (Bell and Sons); "Floral Dissections," Rev. G. Henslow (Edw. Stanford); "Contributions to our Knowledge of the Arctic Regions," Part 1 (Edw. Stanford); "Proceedings of the Aberdeenshire Agricultural Association," Sessions 1878; "A Manual of Scientific Terms," Rev. James Stormouth (Maclachlan and Stewart, Edinburgh); "Hand List of Mollusca in the Indian Museum," Part 1, Godfrey Nevill (Calcutta); "Chronological History of Plants" Charles Pickering (Trübner); "Report of New York State Survey, 1878," James F. Gardner; "Pontresina and its Neighbourhood," J. M. Ludwig (Stanford); "Description physique de la République Argentine," Vols. ii. and v., and Atlas, &c., Dr. H. Burmeister (Paris, F. Savy); "British Birds," G. Peter Moore (J. van Voorst); "A Hunting Expedition to the Transvaal," D. Fernandes das Nives (Bell); "Origin of the Laws of Nature," Sir Edw. Beckett, Bart. (S.P.C.K.); "Lectures on Practical Astronomy," Rev. J. Challis (Deighton, Bell, and Co.); "Arithmetic," J. W. Marshall (Marcus Ward); "Scientific Lectures," Sir John Lubbock (Macmillan and Co.); "Agricultural Botany, Turnip-singling," A. Stephen Wilson (Smith, Aberdeen); "The Rights of an Animal," E. B. Nicholson (Kegan Paul); "Commercial Organic Analysis," Vol. i., Alf. Allan (Churchill); "Demonology and Devil-Lore," 2 vols., M. D. Conway (Chatto and Windus); "Atlas of Histology," Part 5, Smith and Klein (Smith, Elder).

THE additions to the Zoological Society's Gardens during the past week include a Crested Pigeon (*Ocyphaps lophotes*) from Australia, presented by the Rev. A. H. Glennie; two Lesser Redpoles (*Linota linaria*), British, presented by Dr. Bree, F.Z.S.; a Common Lobster (*Homarus vulgaris*), British Seas, presented by Mr. G. H. Jones, F.Z.S.; two Black-tailed Godwits (*Limosa melanura*), British, two Beautiful Parrakeets (*Psephotus pulcherrimus*) from Australia, four White Storks (*Ciconia alba*), European, two Tuatera Lizards (*Sphenodon punctatus*) from New Zealand, purchased; two Geoffroy's Doves (*Peristera geoffroii*), three Spotted-billed Ducks (*Anas pæcilorhyncha*), three Australian Wild Ducks (*Anas superciliosa*), three Chilian Pintails (*Dafila spinicauda*), bred in the Gardens.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

MR. AND MRS. HENRY SIDGWICK contribute each 500*l.* to the building fund (11,000*l.* being required) for the new hall to be built at Newnham, Cambridge, for women students, under the "Newnham College Association" for the advancement of education and learning among women in Cambridge. Miss Clough, the principal of Newnham Hall, whose unpaid services are of incalculable value, also gives 500*l.* to this new building, which will include lecture-rooms, &c., as well as residence for thirty. Prof. and Mrs. J. C. Adams, Dr. and Mrs. Bateson, Mr. and Mrs. Peile, &c., are among the large donors, and the Rev. Coutts Trotter, of Trinity College, is a donor of 100*l.*

THE Chemical Laboratory of Newnham Hall, which has cost over 1,000*l.*, is now complete, and will be available for all the students of the Newnham Association. So also will be the Gymnasium and Garden. The Old Newnham Hall company is now merged in the new association, differing from the former in the contributors not being permitted to receive any profits. It is needless to add that the old association did not actually receive any profits, though registered as an ordinary "limited" liability company.

THE main purpose of the Irish University Bill, introduced to the House of Lords on Monday by Government, seems to be the creation of an institution similar to that of London University, prepared to grant degrees to all comers. In order to do this Government propose to establish a new University, to consist of a Chancellor and Senate to be appointed by the Crown, and not to exceed thirty-six in number. But though nominated in the first instance by the Crown, arrangements would be made to fill up a certain number of the vacancies afterwards, so that Convocation might have the election of six members of the Senate. The Government proposed, with regard to the Convocation, that it should consist of the graduates who had obtained their degrees in this University, or any one who might be transferred to or become graduates from the other University. The Government proposed that the Senate should elect the Vice-Chancellor, and also that the new University thus constituted should appoint examiners and conduct examinations for matriculation and degrees, and that it should confer degrees in all faculties except theology. They proposed that those degrees should be granted without regard to residence in any particular college, that the examinations for those degrees should be with regard to the standard of efficiency only, and that the degrees should be conferred on all who came up to the standard, and they proposed that there should not be any professors or lecturers connected with the University, thus following the example of the University of London. The Government are of opinion that steps should be taken for the dissolution of Queen's University, and that graduates of Queen's should become graduates of the new University, and those who were matriculated students of one should be so of the other, and possess all the same privileges and advantages in the new University as they did in Queen's.

FIVE years ago, when the late Lord Lawrence publicly presented the first Mortimer Scholarship Prize, Prof. Huxley made a speech which has proved prophetic. It was to the effect that the ladder of Board School education planted in the gutter might land such lads as Baker in the highest universities. That lad enjoyed his Mortimer Scholarship (worth 30*l.*) one year. He then obtained a scholarship in the City of London School. In four years more he obtains an open scholarship in Trinity College, Cambridge, at seventeen years of age. An immediate result of this success of the Elementary Education Act is that the Brewers' Company have since presented two scholarships to the London School Board.

IT was stated in Parliament on Monday that a petition having been presented to the Queen in Council, praying Her Majesty to grant a charter for a new Northern University, to be called the Victoria University, Her Majesty had been advised to grant the petition.

SCIENTIFIC SERIALS

Annalen der Physik und Chemie, No. 5.—From experiments, here described, on magnetisation of steel during the hardening process, Herr Holtz concludes that the method offers no advantages in practice. Magnets can, indeed, be thus made six times as strong as by the ordinary method, but this holds good only for extremely weak magnetising force; as you increase the force the difference rapidly decreases, and ere long becomes in favour of the ordinary method.—Herr Schellbach and Herr Boehn describe some instructive effects got on plates covered with carbon-dust placed under a discharger of a Leyden jar. Various devices were introduced for reflection, &c., of the sound-waves, whose mechanical action is indicated by the resultant figures on the plates.—Herr Wroblewski finds that a tenfold increase of the viscosity of water (by dissolving a crystalloid or colloid in it) produces only a five or six-fold diminution of the value of the constant for diffusion of carbonic acid in pure water.—The lowering of tone undergone by a sounded tuning-fork when immersed in liquids having been attributed by Herr Auerbach to the circumstance that kinetic energy is dispersed in incompressible liquids in another way than in gases (the changes of state in liquids being supposed to occur isothermally, in gases isentropically), Herr Kolacek offers another explanation based on mechanical principles.—In an inaugural dissertation Herr Freund writes on some galvanic properties of aqueous metal-salt solutions, his experiments having been made by Paalzow's method; and the results for sulphate of copper solution differing about 5 per cent. from those formerly obtained by Herr Beetz, he offers an explanation of this; which, however, Herr Beetz rejects, adhering to his own numbers.—Herr Ketteler contributes a paper on the theory of double refraction, and Herr Rammelsberg writes on some topics in mineralogical chemistry.

Morphologisches Jahrbuch, vol. 5, part 1.—This number contains no fewer than thirteen lithographic plates. Three of these illustrate Oscar Hertwig's second part of his memoir on the piscine dermal skeleton. He deals now with the ganoids (Lepidosteus and Polypterus).—R. S. Bergh, on the early development of the ovum of *Gonothyræa loveni* (Allman), 2 plates, 40 pages.—G. Born, the nasal cavities and passages of the amniotic vertebrata (3 plates, and about 80 pages).—O. Kling on *Craterolophus tethys*, a contribution to the anatomy and histology of the Lucernaridæ (3 plates, 26 pages).—A. Rauber, on the occurrence of budding among the vertebrata (2 plates).

Zeitschrift für wissenschaftliche Zoologie, vol. 32, part 2.—J. E. Boas, the teeth of the Saroids (25 pages).—R. Wiedersheim, the anatomy of *Amblystoma weismanni*, with two large coloured plates.—R. Greef, the pelagic annelids of the Canary Islands (45 pages, 3 plates); with discussions on the comparative anatomy of the Tomopteridæ, and figures and descriptions of Pontodora, &c., and several new species of Tomopteris.—H. Simroth, on the locomotion of Limax; two plates figuring *L. cinereoniger*.—J. Ciamician, on the histology and embryology of *Tubularia mesembryanthemum* (25 pages, 2 plates).

Kosmos, vol. 3, part 1, April, 1879.—The first article, "Natural Science in the Middle Ages," by Fritz Schultze, refers especially to Roger Bacon.—The controversy about *Planorbis multiformis* (1st art.), by F. Hilgendorf, is, among other figures, illustrated by a series of outlines of the different varieties of *P. multiformis*, as seen in section, &c., and referring to Sandberger's views.—Hermann Müller contributes an article of 16 pages, on Samuel Butler's "Life and Habit."

Reale Istituto Lombardo di Scienze e Lettere, Rendiconti, vol. xii. fasc. x.—We note here the following:—Researches on the electric conductivity of carbon (continued), by Prof. Ferrini.—On a surface of capillarity, by Dr. Poloni.—Influence of climate and soil on the combustibility of tobaccos, by S. Cantoni.

Journal de Physique, June.—Spectroscope for observation of ultra-violet radiations, by M. Cornu.—Spectrometric measurement of high temperatures, by M. Crova.—Magnetic rotatory power of gases, by M. H. Becquerel.—Magnetic rotatory power of liquids and their vapours, by M. Bichat.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, June 19.—"Researches in Chemical Equivalence. Part III.—Nickelous and Cobaltous Sulphates." By Edmund J. Mills, D.Sc., F.R.S., and J. J. Smith.

Although the chemistry of nickel and cobalt is interesting from many points of view, it is more especially attractive from the probable isomerism of these metals. Their combining proportions, in fact, according to the most valuable evidence we possess, appear to be entirely the same. The authors, therefore,

thought it very advisable to inquire on what terms these metals might prove to be mutually equivalent: and the particular equivalence they have examined has been equivalent precipitability of the sulphates, by sodic hydrate, from an aqueous solution.

After describing the mode of preparation of the pure sulphates, the authors give an experimental criticism of the methods of separating nickel from cobalt, finally adopting the one devised by Gibbs. Having then fixed on the method of separation, 1 per cent. solutions of nickelous and cobaltous sulphates were prepared, and a solution of sodic hydrate, of which 10 cub. centims. were capable of precipitating ·8248 grm. of nickelous or cobaltous sulphate. This sodic hydrate was made from sodium, and kept in glass bottles coated internally with a thick layer of paraffin.

A series of nine experiments was made, in which the relative weights of nickelous or cobaltous sulphate present, varied from ·1 to ·9 grm.; the total weight of nickelous and cobaltous salt, and the volume of the solution being, however, always the same, viz., 1 grm. and 100 cub. centims. The experiments were conducted as follows:—The bottles containing the solutions of the sulphates and the sodic hydrate were immersed in a trough into which there was a constant flow of water to bring them to a constant temperature. The necessary quantities of nickelous and cobaltous solutions were then carefully measured out, mixed, and the temperature observed. 10 cub. centims. of sodic hydrate was then added, the solution stirred vigorously, and the temperature again observed. The precipitate was then filtered off as quickly as possible (an aspirator being used to facilitate the filtration), and washed, first with cold and then with hot water. It contained sodic sulphate, cobaltous sulphate and hydrate, and nickelous hydrate, all of which were analytically determined.

If n represent a weight of nickelous sulphate taken, and ν be the hydrate (calculated to sulphate) obtained from it through precipitation, the experiments show that $n = (1 + {\cdot}21940\, n)\, \nu$. Similarly, for cobalt, $c = 1{\cdot}1845 y$. The authors give the following conclusions as the result of a discussion of their work:—(1) *The precipitability of nickelous sulphate is directly proportional to its mass*; (2) *The precipitability of cobaltous sulphate is an invariable quantity*; (3) *For an equal weight nickelous and cobaltous sulphates are equally precipitable; the attraction of the one towards the reagent being then inverse to that of the other.*

They accordingly write $\phi\,(NiSO_4) = (\phi\, CoSo_4)^{-1}$.

"On the Formation of Hydrocyanic Acid in the Electric Arc." By James Dewar, M.A., F.R.S., Professor of Chemistry to the Royal Institution.

The inference drawn from experiments given in the paper is that the reaction is in all probability the result of acetylene reacting with free nitrogen, as when induction sparks are passed through the mixed gases, viz.—

$$C_2H_2 + N_2 = 2HCN,$$

and that the hydrogen is obtained from the decomposition of aqueous vapour, and the combined hydrogen in the carbons. It is possible, traces of alkaline salts in the carbon poles may favour the formation of hydrocyanic acid, but, as all attempts to purify the poles so as to stop the reaction failed, I am inclined to believe it is a direct synthesis. The acetylene reaction is one of the many remarkable syntheses discovered by Prof. Berthelot of Paris. The presence of sulphuretted hydrogen is doubtless due to the reduction of the sulphates, invariably present in the ash of the carbon.

"An Account of Experiments on the Influence of Colloids upon Crystalline Form, and on Movements observed in Mixtures of Colloids with Crystalloids." By William M. Ord, M.D. Lond., F.L.S. Communicated by J. Simon, C.B., D.C.L., F.R.S.

Chemical Society, June 19.—Dr. Roscoe in the chair.—The following papers were read:—On Gardenin, by Dr. Stenhouse and Mr. C. E. Groves. This substance has been extracted from "Dekamali gum," the resin of the *Gardenia lucida*. Gardenin by treatment with nitric acid is converted into a mass of red crystals of gardenic acid; an acetyl derivative has been obtained. Gardenic acid in contact with sulphurous acid is converted into hydrogardenic acid.—On dry copper-zinc couples and analogous agents, by Dr. J. H. Gladstone and Mr. A. Tribe. By heating nine parts of coarse zinc filings with one part of finely divided copper in a flask over a Bunsen flame until the filings begin to lose their shape, dark grey granular masses are obtained. These masses constitute the dry copper zinc couple, which is found to equal in activity the well-known moist copper-zinc couple, prepared by immersing zinc foil in copper sulphate solution; ten grammes of the dry couple convert 5 cc. of ethyl-iodide into zinc ethiodide in about six minutes. Couples of other metals were tried, but none were found to be in practice superior to that formed of copper and zinc.—On the action of sulphuric acid on the hydrocarbons of the formula $C_{10}H_{16}$, by Drs. Armstrong and Tilden. The authors deny the statement made by Ribau that the product of the above action yields a distillate when steam is passed through it consisting of cymene with a liquid isomeride of terpene; the so-called terebene is really inactive camphene, melting at 47°. The crude colophene remaining after the distillation in steam yields on distillation 10–30 per cent. of volatile substances—inactive camphene, terpilene, a paraffin-like body, an optically inactive camphor, &c.—Researches on the terpenes, camphor, and allied compounds, by Dr. Armstrong. Part I. On hydrocarbons associated with the terpenes, and on the formation of cymene from terpenes and allied compounds. II. On the action of iodine on terpenes. III. Camphor derivatives.—Contributions to the history of starch and its transformations, by Messrs. H. F. Brown and Heron. The authors have examined in a most elaborate manner the action of malt extract at various temperatures and under varied conditions, on potato starch.—On the determination of nitric acid by means of indigo, with especial reference to water analysis, by Mr. R. Warington. The author gives the results of much experience with this process, which has the advantages of great simplicity, speed, and delicacy; the results are, however, conditioned by many circumstances which must be known before the method can be applied with delicacy.—Notes on the purple of the ancients, by Dr. E. Schunck. The author has worked up about 400 specimens of *Purpura lapillus*, a shell-fish found at Hastings, and extracted the cyst containing the yellowish secretion which in sunlight becomes purple and forms a permanent dye stuff. The colouring matter apparently belongs to an unknown member of the indigo-blue group.—On the heat of formation of aniline, picoline, toluidine, lutidine, pyridine, dipicoline, pyrrol, glycerine, furfurol, by W. Ramsay.—On ethylenic chlorosulphocyanide and its oxidation into ethylenic chlorosulphonic acid, by J. W. James.—On mixing and heating potassium sulphocyanide with alcohol and chlorobromide of ethylene, potassium bromide, and chlorosulphocyanide of ethylene were obtained. The latter with nitric acid gave chloroethylene sulphonic acid, the silver salt of which heated with ammonia furnished taurin.—On the boiling points of certain metals and metallic salts, by Dr. T. Carnelly and Dr. W. Carleton Williams.

Linnean Society, June 19.—Prof. Allman, F.R.S., president, in the chair.—Attention was called to two volumes folio on the British fresh water fishes by the Rev. W. Houghton. These, recently issued, illustrate in colours all the known and new species.—The Secretary read a paper on a remarkable branched *Syllis* from the *Challenger* expedition, by Dr. W. C. McIntosh. This Polychæte worm *S. ramosa* was got in the basal canals of a hexactinellid sponge, dredged near Zebu, Philippines. Thread-like in thickness, the branches are intricately arranged among the meshes of the sponge, and it appears that but one head must serve for many branches. Buds and secondary buds are very numerous on the latter, and in a free female pedal bristle-tufts were observed. A fragment of a different form is suggested, as possibly the male of the foregoing rare example of a truly branched annelid, differing in most particulars from anything heretofore recorded.—There followed remarks on *Carpesium* (*C. cernuum*) as indigenous to Australia, by F. M. Bailey. The author supports Mr. Bernay's view of this plant not being introduced, but undoubtedly endemic.—Mr. A. Hammond read a paper on the thorax of the blowfly. Most authorities at present recognise the great preponderance of the mesothorax over the other two segments, but do not fix the limits of each. The author refers to the integumentary parts entering into the thorax of insects, as enumerated by Audouin, and also especially to the views held by Westwood, Burmeister, Lowne, and others. Afterwards he gives a full description of his own dissections and preparations, and reasons for dissent from the majority of workers, though with evident inclination to Audouin's opinions. He concludes that, from the analogy presented by other insects, from the evidence derivable from the phenomena of developmental change, and from a study and consideration of the nervous and muscular systems all combine to show that the thorax of the Diptera, as illustrated in the blowfly, is almost exclusively mesothoracic, a conviction quite at

variance with that promulgated by Lowne in his researches on the blowfly.—The Rev. J. M. Crombie gave an enumeration of the lichens in the herbarium of the late Rob. Brown in the British Museum. These were collected 1802–5 during the notable voyage of Capt. Flinders to New Holland and Tasmania. No complete catalogue of these lichens was published by Brown, though many bear his MS. names, and only the more common species were indicated in the Appendix to the above voyage. A paucity of "saxicole" species in this as in more recent collections of exotic lichens is to be regretted.—Mr. G. Busk read a paper on recent species of Heteropora, founded chiefly on material got in the *Challenger* Expedition. Hitherto material for a knowledge of these has been among fossil forms, but quite lately Mr. Waters has drawn attention to a recent example in the British Museum, said to be from Japan. Mr. Busk now considerably adds to our information on the living types, and enters into several structural peculiarities observed by him.—The abstract of a contribution to the flora of Northern China, by Messrs. J. G. Baker and S. Le M. Moore was read. Some 600 specimens now deposited in the Kew herbarium, and collected by Mr. John Ross in the province of Selim King 40° to 42° N. lat. of the Celestial Empire, furnish the basis of this botanical contribution. Though many species among these are already known, yet the discovery of such forms as *Exochorda serratifolia*, an addition to a genus that has for years remained monotypic—*Saxifraga Rossii*, *Brachylites paridiformis*, and *Betula exaltata*—along with several altogether new species, render the collection valuable. These form a good adjunct to the researches on this relatively unfrequented region; but a knowledge of which is rapidly being accumulated, chiefly through the labours of Maximowicz, Hance, and Franchet.—The Rev. J. M. Crombie briefly indicated the substance of a reply by him to Dr. Stirton's remarks on his paper on the *Challenger* lichens.—Then followed a paper by Pastor H. D. J. Wallengren (of Sweden), on the species of Caddis flies (*Phryganea*) described by Linnæus in his "Fauna Suecia," with notes on, and communicated, by Mr. R. McLachlan. In this communication some twenty-five species undergo a critical revision and determination as identified from the living insects and Swedish entomological collections. Mr. McLachlan, however, does not concur with all the Pastor's conclusions.—On the Bell Bird, by Dr. J. Murie, was a paper taken as read.—Mr. Chas. Holme (Bradford) was elected a Fellow of the Society.

Paris

Academy of Sciences, June 23.—M. Daubrée in the chair.—The following papers were read:—On the absorption, by the atmosphere, of ultra-violet radiations, by M. Cornu. That the solar spectrum extends beyond what the most favourable observations present of it, seems probable from its almost sudden termination on the most refrangible side (in photographs), and the results of comparing this spectrum with that of iron vapour in the electric arc. The atmospheric absorption of ultra-violet radiations is demonstrated by introducing a tube 4 m. long, closed at the ends with fluor spar, between the collimator and the prism of a spectroscope. When the tube is full of air, line 32 of the aluminium spectrum (from electrodes of that metal transmitting the induction-spark) is invisible; but as vacuum is gradually produced, the line appears.—Remarks on a note of Admiral Mouchez, by M. Faye. He argues against the watchmakers being called on to determine experimentally the thermometric correction of the instruments they supply to merchant vessels. These vessels should have the same advantages as the navy in this respect.—Action of so-called poisons of the heart on the snail (*Helix pomatia*), by M. Vulpian. Alcoholic extract of onaye (*Strophantus hispidus*, D.C.), was taken as type of poisons stopping the heart with the ventricle in systole; *muscarine*, with the heart in diastole. The action in both cases was similar to that in frogs. The antagonism observed in mammalia between the effects of muscarine and those of sulphate of atropine, was also observed in snails. The hearts of crustaceans were not, apparently, affected by the two typical poisons named.—On an arithmetical property of a certain series of whole numbers, by Prof. Sylvester.—Inexact application of a theorem of dynamics, by MM. Bertin and Garbe, to explain the motion of the vanes of a radiometer. He disputes the assertion that the motion is produced solely by gaseous matters within the globe (the inference drawn by the authors named from a dynamical theorem). Considering the cause of motion complex, he suggests experiment in the direction of varying the substance and surfaces of the vanes with special regard to the calorific and luminous properties of the materials used; altering the luminous rays especially by polarising them in different directions relatively to the vanes; suspending the globe on two very fine points and inclosing it in a receiver exhausted of air.—On the means of working automatically the upper tube of the economising apparatus constructed at the sluice of Aubois, by M. de Caligny.—On the interoceanic maritime canal, by M. de Lesseps. Some preparatory operations are mentioned. Dr. Companyo, of Perpignan, who directed an important sanitary service in the Suez Canal works, has been sent to Panama to study the best means of preserving the health of workmen; and agents and correspondents have been charged to enlist the most suitable workmen in America.—M. Lissajous was elected Correspondent in Physics, in room of the late Dr. von Mayer.—Map of the solar spectrum, by M. Thollon. This new map, made with the aid of his powerful spectroscope in Italy, is 10 metres long, and contains about 4,000 lines (Ångström's contained 1,600 in a length of 3 metres). M. Thollon remarks on the singular resemblance of the groups A and B, and gives a four-fold classification of solar lines, viz.: 1. Nebulosity without nucleus. 2. Nucleus without nebulosity. 3. Nebulosity predominating. 4. Nucleus predominating. He describes the instruments with which he operated.—On the reappearance of phylloxera in vineyards subjected to insecticide operations, by M. Marion.—On the positions of the Comet Tempel II., 1867, deduced from four first observations at the observatory of Rio de Janeiro, by M. Cruls.—Resolution of systems of linear congruences, by M. Demeczky de Gyergyoszentmiklos.—Addition to a previous note on the series of Laplace, by M. de Saint Germain.—Study of the molecular constitution of liquids by means of their coefficient of expansion, their specific heat, and their atomic weight, by M. Pictet.—Explanation of the bolide at Geneva on June 7, 1879, by M. Oltramare. He considers such a phenomenon arises from electricity detaching a portion of the electrified cloud.—Study on alloys of lead and antimony and especially on the liquations and supersaturations they present, by M. De Jussieu.—On the production of hydrocellulose, by M. Girard. He gives three methods of producing it.—On the retrogradation of superphosphates, by M. Joulie.—On the respiratory apparatus of Ampullaria, by M. Sabatier.—Experimental researches on the therapeutic value of intravenous injections of milk, by MM. Bechamp and Baltus. The transfusion of milk within certain quantitative limits (comparatively extended) is harmless in the dog, but has too little therapeutical value to be substituted for transfusion of blood.—On the total absence of amnios in the embryos of the hen, by M. Dareste.—Prof. Draper presented a photograph of the solar spectrum and that of oxygen.

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